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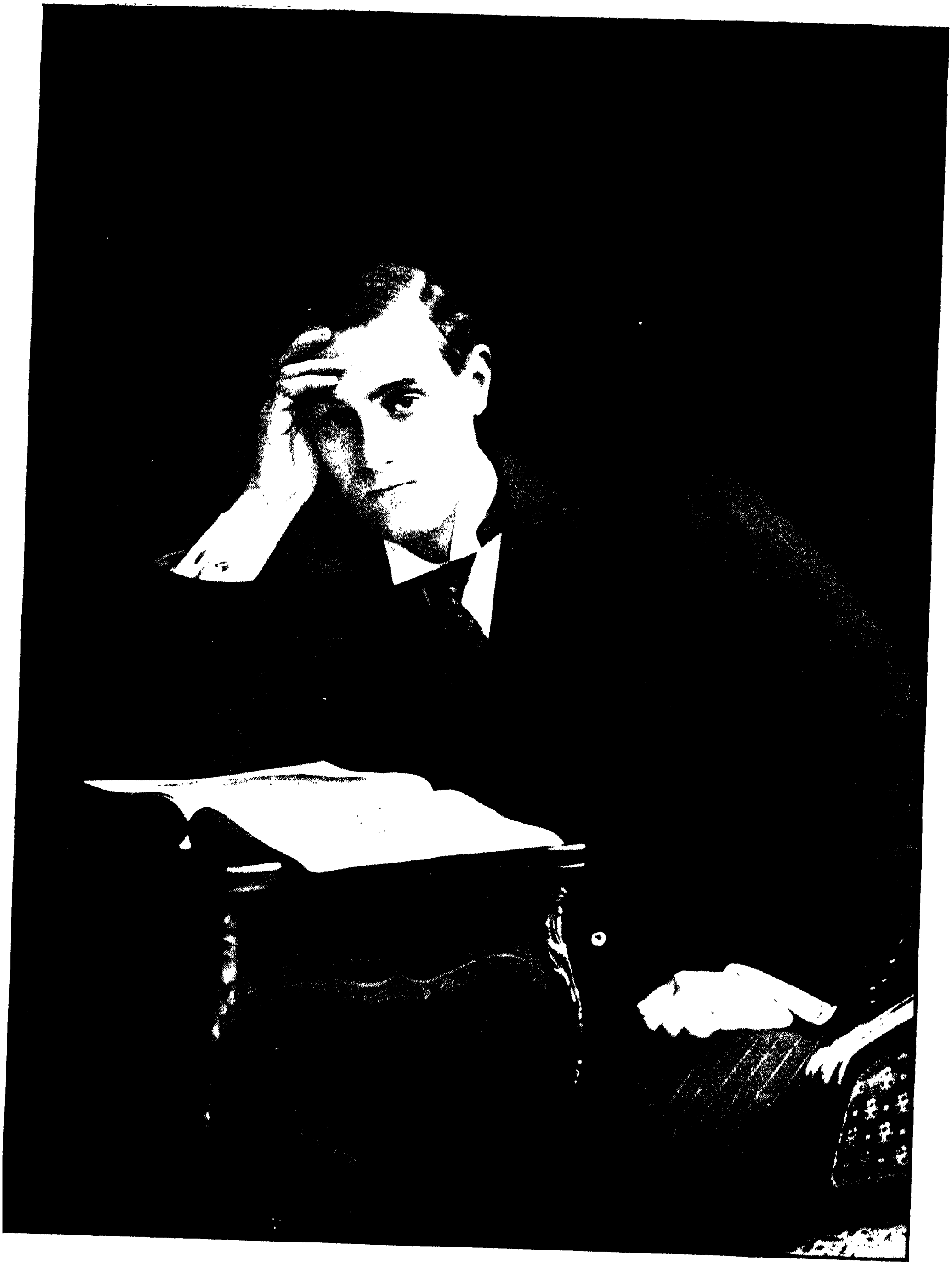


MARQUESS OF LINLITHGOW, D.L.,
Chairman, Royal Commission on Agriculture.

ROYAL COMMISSION ON AGRICULTURE.

CHAIRMAN'S INAUGURAL ADDRESS.

The following is the inaugural address delivered by the Most Hon'ble the Marquess of Linlithgow, Chairman of the Royal Commission on Agriculture, at the first meeting of the Commission :—

" Gentlemen,—This is the first time that we have met as a Commission, and I propose, with your permission, to make one or two preliminary observations.

" By the terms of the King Emperor's Commission which you have just heard read, we have had laid upon us a most important duty. A long enquiry, far journeyings, and much hard work lie before us. At such a moment we may well seek inspiration and encouragement in the speech of His Excellency the Viceroy, delivered at the Conference of Ministers and Directors from Provincial Governments in Simla in June of this year. As one who has served the cause of agriculture both on the farm and as Minister of Agriculture in Great Britain, His Excellency brings to bear upon the problems with which we are concerned a mind experienced alike in the administrative and in the practical spheres of husbandry. May we not take it as the best of omens that our stage is set in the period of Lord Irwin's Viceroyalty ? I would draw your attention in particular to one sentence in that speech. His Excellency reminded his audience that the ' Indian agriculturist is the foundation upon which the whole economic prosperity of India rests and upon which the structure of her social and political future must in the main be built.' Gentlemen, these are words which we shall do well to keep ever present in our minds.

" Our thanks are due to the Hon'ble Sir Muhammad Habibullah Sahib Bahadur and to the Ministers and Directors of Agriculture who attended the Conference, and to those officers of the Government of India and of the Provincial Governments who have provided the Commission with an able and informing series of memoranda.

" In approaching the subject of our enquiry, we are face to face with an indigenous system of agriculture which has been built up, through long centuries, mainly by empirical means, by the slow but sure method of trial and error. It is a venerable structure whose worth has been proved through the years, and those who have studied it most closely are not those who criticise it lightly.

" That it is capable of improvement none will deny. Indeed the history of the Agricultural Departments in India and of their successful endeavours, in recent years, to graft upon the parent stock the new growth of progressive and scientific practice, gives good ground for the hope that the future of Indian agriculture is a bright one.

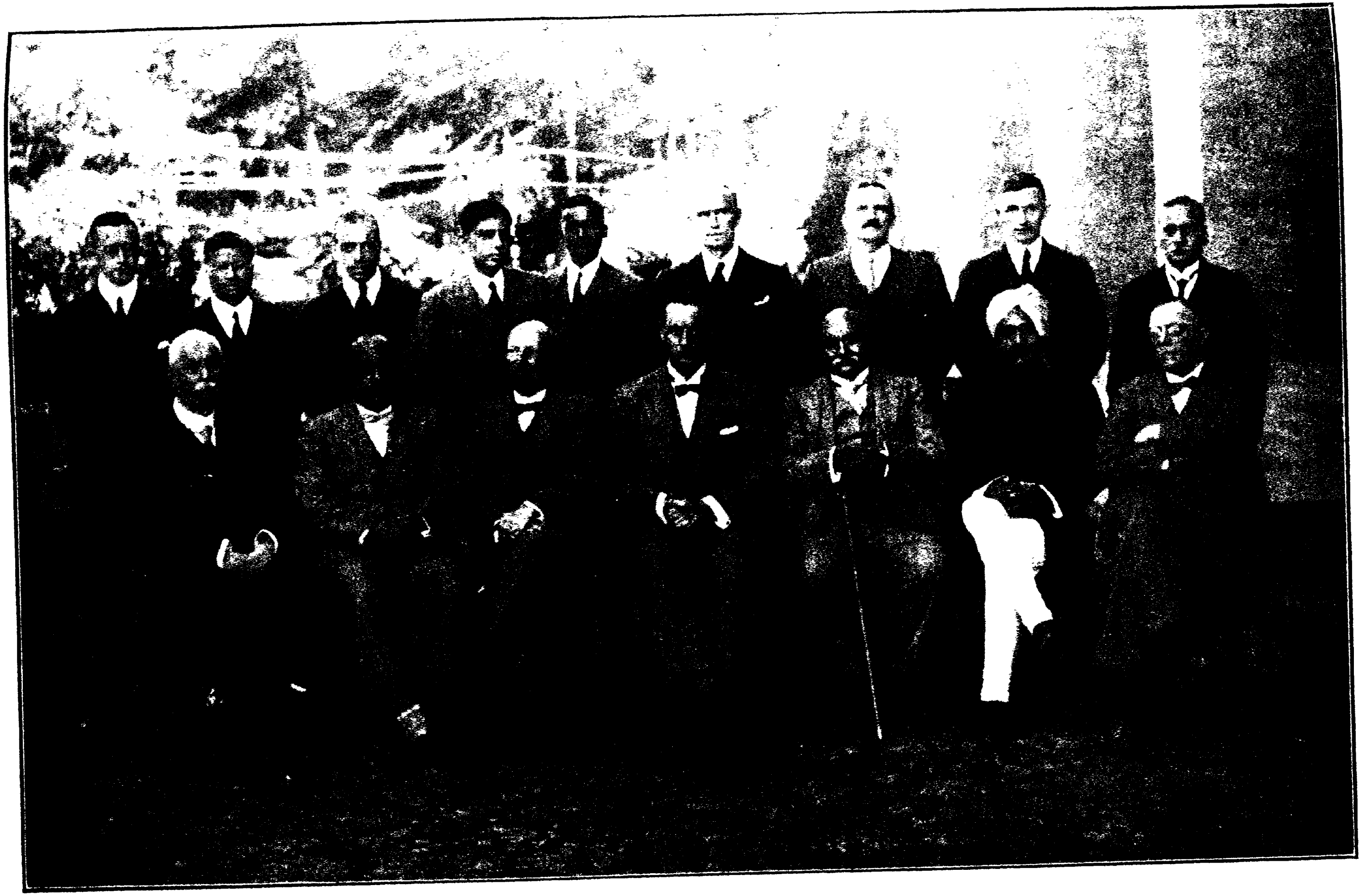
" During the course of our enquiry we shall no doubt hear a great deal of evidence upon highly technical questions. That does not mean that, as a Commission, we shall compete in purely technical matters with those who devote their lives to such work in India. Indeed if we were to be lured into any attempt to appreciate the technical details of, for instance, agricultural research, we should cloud our vision by a vast mass of material and we should delay, beyond all reason, the conclusion of our labours.

" The problems of Indian agriculture no doubt vary greatly from province to province : and we shall have the opportunity of examining them in the course of the next few months. But, however much they may differ, they must yet present certain common features. For they all react upon the well-being of the actual cultivator of the soil, whose economic prosperity we are here to seek to advance ; and they are all affected by certain economic factors, arising from the position of individual cultivators and from the general organization of the agricultural life of India, factors which are not peculiar to any single province. Our duty will be to examine these problems, and to form the best judgment that we can with regard to them. I recognize that the result of our work will depend in large degree upon the extent to which we may be able to commend any conclusions at which we may arrive, sound as I hope they may be, to progressive and intelligent Indian agricultural opinion.

I think I may claim that the Commission over which I have the honour to preside is one that is entitled to command a wide measure of the public confidence which is requisite if we are to succeed in the task to which we have set our hands. We are fortunate in being able to combine scientific knowledge, drawn from both Indian and English sources, and perhaps I may be allowed to add from Scotland, with the practical experience possessed by those who have passed their working life in close touch with the question we are to explore.

" We have a long and arduous road to travel and one strewn with many difficulties. I believe we shall compass that journey and overcome those obstacles, provided we keep steadily before us that our duty is to advance the prosperity and the well-being of the cultivators of India, one of the most important, and potentially powerful, agricultural communities of the world."

PLATE II.



MEMBERS AND SOME OF THE STAFF OF THE ROYAL COMMISSION ON AGRICULTURE.

PLATE III.

COLONEL G. K. WALKER, C.I.E., C.B.E., V.D., F.R.C.V.S.

ORIGINAL ARTICLES

COLONEL G. K. WALKER, C.I.E., O.B.E., V.D., F.R.C.V.S.

AN APPRECIATION.

The news that Colonel G. K. Walker, the doyen of the Veterinary Service in India, is now on leave preparatory to retirement, will be received with the utmost regret by his large circle of friends in India, coupled, in the case of his own Service, with a feeling of irrepara le loss.

Colonel Walker is the last member left in the Service of that small band of Army Officers who elected for civil employ to form the Indian Civil Veterinary Department. After a few years' service in the Army Veterinary Department (now the Royal Army Veterinary Corps), Colonel Walker joined the Indian Civil Veterinary Department in 1897, and almost immediately proceeded to Muktesar as Assistant Bacteriologist. From 1901 to 1912 he was in charge of the Punjab Civil Veterinary Department, from 1914 to 1918 in charge of the Bombay Civil Veterinary Department, and from 1919 to 1926 he was Principal of the Punjab Veterinary College at Lahore.

Colonel Walker's great natural aptitude for organization and administration heavily loaded the dice in his favour in what was, at any rate when he joined it, a pioneer department. His whole official career was eminently successful, but possibly his greatest achievement was what might almost be described as his creation of the Punjab Veterinary Department. He took over practically nothing in 1901, and in 1912 he handed over a well organized, efficient, beneficent department, provided with hospitals in almost every tehsil of the province. Apart from his abilities as an organizer and administrator, Colonel Walker was always able to get on with and hold his own with the District Official and was quick to gain the confidence of the Indian stock-owner. No doubt he owed much of his success to these qualities.

The present generation of veterinary officers will always regret that questions of economy in recent years resulted in the abolition of the head of the Veterinary Department before Colonel Walker was senior enough for the appointment. This, no doubt, was a misfortune both for India and the Service. Colonel Walker would have been exactly suited to such an appointment, and no doubt he would have done as much for India and the Service generally as he did for the Punjab and its Provincial Service.

In recent years Colonel Walker has devoted his energies to the cause of veterinary education; his experience permitted him to see the subject from the view point of both the teacher and the district superintendent. He was mainly instrumental in the introduction of the four years' curriculum at the Punjab Veterinary College.

Colonel Walker leaves India loaded with well deserved honours after a record of achievement of which both he and his Service may well be proud. We wish him the best of luck in the old country. [R. B.]

IMPROVED METHODS OF SUGARCANE CULTIVATION IN NORTH BIHAR.

BY

WYNNE SAYER, B.A.,
Secretary, Sugar Bureau, Pusa,

KASANJI D. NAIK, M.A.,

AND

HARDAYAL SINGH RANDHIROT, L.Ag.

The activities of the Sugar Bureau on the agricultural side during the last five years consisted mostly in testing new Coimbatore seedlings, arranging for mill trials of seedlings found to be superior to local varieties in point of yield and other desirable agricultural characters, and in evolving improved methods for cane cultivation suitable for conditions prevailing in the White Sugar Tract. The recommendations detailed in this article have all been based on experiments made on a large scale in favourable as well as unfavourable seasons, with implements and manures likely to be taken up by the growers as being within their reach. The soil of the New Area at Pusa, where the writers carried ou their sugarcane experiments, is not representative of the good cane soils in Bihar. On analysis it showed the following mechanical and chemical composition :—

**Mechanical analysis.*

	Surface soil 0″—6″	Sub-soil 6″—1′ 6″
	Average of 12 samples	Average of 12 samples
24 hours' clay	2·57	3·88
6 „ silt	2·40	3·66
2 „ „	2·19	3·01
½ „ „	3·94	5·71
10 minutes „	9·65	10·14
75 seconds fine sand	43·12	39·15
Sand	36·13	34·45

* The analysis was made by the Imperial Agricultural Chemist, Pusa, to whom our acknowledgments are due.

**Chemical analysis.*

	Surface soil 0″—6″	Sub-soil 6″—1′ 6″
	Average of 12 samples	Average of 12 samples
Moisture	0·34	0·44
Loss on ignition	1·45	1·32
Sand	62·57	59·10
Iron oxide (Fe_2O_3)	2·03	2·33
Alumina (Al_2O_3)	3·50	3·73
Phosphoric acid (P_2O_5)	0·09	0·08
Potash (K_2O)	0·37	0·39
Lime (CaO)	15·85	17·55
Magnesia (MgO)	0·83	1·30
Carbon dioxide (CO_2)	12·97	13·76
Available P_2O	0·00106	0·00044
Available K_2O	0·00740	0·00660
Total nitrogen	0·042	0·030

It will be seen that the soil is deficient in available P_2O_5, and nitrogen is not very high. There is, however, sufficient lime and potash.

Pusa is situated in 25° 59′ N. Lat. and 85° 40′ E. Long., and has average humidity and monthly temperatures (averages of last four years) as under :—

Observations in shade at 8 a.m.

Month	Humidity	Temperature	
		Maximum	Minimum
		°F.	°F.
January	90·7	74·1	48·3
February	80·2	79·1	51·7
March	58·3	92·5	60·6
April	57·4	99·2	71·9
May	64·6	102·0	75·4
June	78·4	97·3	78·9
July	89·6	90·1	83·5
August	89·3	90·7	78·7
September	89·2	89·5	77·5
October	86·0	88·5	70.2
November	87·9	82·6	59·2
December	92·9	75·9	51·2

* The analysis was made by the Imperial Agricultural Chemist, Pusa, to whom our acknowledgments are due.

The average rainfall in Pusa for the 20 years 1906 to 1925 comes to 48·13 inches with the distribution as under :—January—0·21, February—0·71, March—0·45, April—0·66, May—1·59, June—8·30, July—11·56, August—14·10, September—8·74, October—1·32, November—0·42, December—0·07.

It rains* here on an average (average of last 16 years) 1½ days in January, 2 in February, 2 in March, 2 in April, 4½ in May, 13 in June, 21 in July, 20½ in August, 15 in September, 4½ in October, 1 in November and 1 in December.

It is not merely the case that in this part of North India better yielding varieties require to be introduced. The actual cultivation of the crop requires to be better done. The preparatory tillage is fair enough. But the ryots here do not even properly strip the leaves off the seed-cane, and do not discard sets showing a reddening of the pith due to red rot, or sets which are riddled by borers. Healthy, well-grown cane stools are not selected for providing the right kind of planting material, and the great importance of planting only sound sets is not realized as it should be. The result is that germination is very uneven, disease is propagated, there are big blanks in the field, and the yields are reduced.

Sugarcane is a nitrogen-loving crop, and in Java, where they grow cane under irrigation, 2¾ cwt. to 5½ cwt. of sulphate of ammonia are given per acre, while here most of the cultivators do not give any thing more than what little farmyard manure they are able to find. The crop thus gets no manurial treatment worth the name. Further, cane is mostly grown without irrigation in North Bihar and planting is usually done in February. By the time the canes have germinated and begun to make some growth, the hot weather sets in, and in April and May when the hot dry winds are blowing, the young canes have to struggle hard to keep themselves alive. It is only from the middle of June onwards when the monsoon breaks that the sugarcane crop has a vigorous growing period with moist heat and rainfall—the two requisites for successful cane growth. The period of growth is too short, lasting only up to the middle of November, as further growth is arrested by the cold weather that sets in. The crop is usually cut in January-February. The cane thus occupies the land for barely 10 to 12 months.

The conditions are different in other prominent sugar producing countries of the world. They have more rainfall than we have here, and again the distribution of this natural precipitation is such that it favours growing thick heavy yielding varieties (see p. 8). The period of growth is not confined to a few months in a year. Thus in Hawaii a cane crop has two periods of vigorous growth and it covers the land for 18 to 24 months. With elaborate irrigation arrangements heavy crops of 45·5 long tons of cane per acre are harvested.

In Java the cane crop takes from 11 to 15 months to come to maturity. The average rainfall is 83 inches. The cane in the early growing period is irrigated and

* A day on which not less than 0·01 inch of rainfall is registered has been taken here to be a day of rainfall.

Average monthly rainfall of important sugarcane regions of the world.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Novr.	Decr.	Annual
India (Pusa)	0·21	0·71	0·45	0·66	1·59	8·30	11·56	14·10	8·74	1·32	0·42	0·07	48·13
Java[1]	14·73	13·82	11·73	7·24	5·04	3·27	1·58	1·30	1·81	4·06	7·13	11·61	83·46
Cuba[3] (19 stations)	1·90	1·50	2·00	2·80	6·80	8·30	5·30	5·80	7·80	7·00	3·60	2·10	54·90
Mauritius[2] (23 stations)	11·50	8·20	11·30	9·10	5·70	4·60	4·30	3·90	2·70	2·60	3·20	7·00	74·20
Province of Negros[4] (Philippine Islands)	7·80	2·85	5·24	3·36	6·21	9·42	10·71	8·94	10·82	14·96	22·14	11·84	114·29
Brazil[5] (Alagoas)	1·80	3·90	4·40	4·30	8·30	11·70	9·20	7·20	4·60	1·30	1·00	2·00	59·70

[1] *Java Archief*, Vol. 34 (1926), pp. 189-196.

[2] *Handbuch der Klimatologie* : Hann.

[5] *Boletim de Normaes.* Directoria de Meteorologica. Rio de Janeiro.

[3] *Rainfall and temperature of Cuba.* Fassig. Trop. Plant. Research Found., Washington.

[4] *Sugar News*, Manilla, 1926.

COIMBATORE CANE 210, PLANT CROP (STRIPPED), PUSA (NEW AREA).

COIMBATORE CANE 213, PLANT CROP (STRIPPED), PUSA (NEW AREA).

given the right manurial treatment. The result is that heavy crops averaging 43·23 tons per acre are obtained in Java.

In Cuba, which occupies such a dominating position in the world's sugar industry, the cane crop remains on the land for 13 to 16 months and the average rainfall for the whole island is roughly 55 inches. Not much attention is paid to the careful cultivation of the crop and the average production is placed at only 25 tons of cane per acre on land recently brought under cultivation and 20 tons per acre on older land.

We in sub-tropical India cannot hope to have the same high yields as in tropical and other favourably situated countries. But that is the greater reason why we should in this part of India give more attention to those matters which are within our control. The greatest of these are the planting of varieties which are found to be the best in point of yield and other agricultural characters for the particular soil and climatic conditions of the locality, selection of healthy sets and giving proper manurial treatment and intercultivation.

New Coimbatore varieties of sugarcane.

The Hemja or Bhurli variety of cane grown in North Bihar does not respond to good cultivation and liberal manuring to the same extent as the cross-bred cane seedlings Co. 210, Co. 213, and Co. 214. A good Hemja crop is up to 400 maunds of cane per acre with the cultivation costs amounting to Rs. 75, while a good crop of Co. 213 will be between 600 and 800 maunds per acre with Rs. 130 as the total cost of cultivation, including green-manuring. Taking the present day reduced price of annas six per maund of cane, a cultivator's gross return from Hemja will be Rs. 150 per acre, while that from Co. 213 will be Rs. 225 to Rs. 300. Deducting the actual costs of cultivation in each case it will be found that while he makes a profit of only Rs. 75 per acre of Hemja, he makes Rs. 95 to Rs. 170 from Co. 213. The writers, therefore, recommend these selected Coimbatore seedling canes for cultivation. Of these, Co. 214 has a crooked habit and a comparatively lower tonnage, but it is the hardiest of the three and is comparatively disease-free though the top shoot borer does a certain amount of damage to this cane. Co. 214 has been found to thrive fairly well even on *usar* soils (made barren by saline efflorescence). It is the earliest ripening variety, and an important group of factories, having found it reasonably satisfactory from the sugar making point of view, have already taken steps to encourage its cultivation by offering a premium.

Co. 210 (Plate IV) does well in light lands and also has been successful in heavy lands which flood to a certain degree. Most growers keep it as a reserve against Co. 213 going out and some actually prefer it. In Saran it is becoming more popular than Co. 213. Though not quite immune, it has been so far found less susceptible to mosaic than Co. 213.

Co. 213 (Plate V) is the most heavy yielding of all the three varieties. But it requires strong land and good manurial treatment. Where it has been properly grown, the yields have been excellent, and its behaviour under improved conditions of manuring and irrigation on the Dowlatpore estate shows what a fine cane it is. It is, however, liable to attacks of smut and mosaic. The damage done is so far insignificant, but it requires close watching.

Co. 205 has been found suitable for low-lying lands that get flooded in rains. It is a late ripening cane, and as one of its parents is *Saccharum spontaneum* it is very hardy and does well even on poor soils. There is already a brisk demand for the seed-cane of this variety.

Improved method of planting.

The ridge-and-furrow method of cane planting, instead of planting in trenches, is quite suitable for conditions here.

For planting, furrows should be opened out 2½ ft. to 3 ft. apart, the distance between rows varying according to varieties—3 ft. in the case of medium thick and 2½ ft. for thin canes—the depth of the furrow depending upon the kind of soil and the season of planting. A double mould board plough is most useful for this purpose (Plate VI, fig. 1). It should have a sub-soiler attached to it to loosen the sub-soil in the furrow and so make it easier for the young rootlets to establish themselves. Cake meal should then be sprinkled evenly in the furrows.

As the Coimbatore canes have long internodes, there are likely to be big blanks in the field if the germination is unsatisfactory through some reason or other, and as the total yield of a crop depends upon a full and uniform growth, it is essential to ensure as few gaps as possible in the rows. It has been found in practice that if the sets are planted eye-to-eye, as shown in Fig. 1 on Plate VII, it gives better results than when placed a few inches apart from one another or when planted end-to-end. Even when there is poor germination and there are attacks of white ants and borers, comparatively fewer gaps are observed when the planting is done according to this method. This no doubt increases the seed-rate. The number of sets planted per acre in this way is approximately 14,000 for Co. 213, 16,000 for Co. 210 and 17,000 for Co. 214. But the cost is more than repaid by the increased outturn.

Again, the doubling of sets at the furrow ends has its advantages. If any one goes round cane fields in Bihar, he will notice that on borders of fields to a considerable depth there are but a few straggling plants, as the headlands usually do not receive the same amount of cultivation as the rest of the field, and insect pests such as white ants are comparatively more active there than inside. In Java they put double sets in the trenches at the border ends, which results in a whole field from the border right up to the other end presenting a uniform crop growth. The senior writers were struck with this practice in Java and found out that, by hand-digging

Fig. 1. D. M. B. Plough (new pattern) with sub-soiler attached behind.

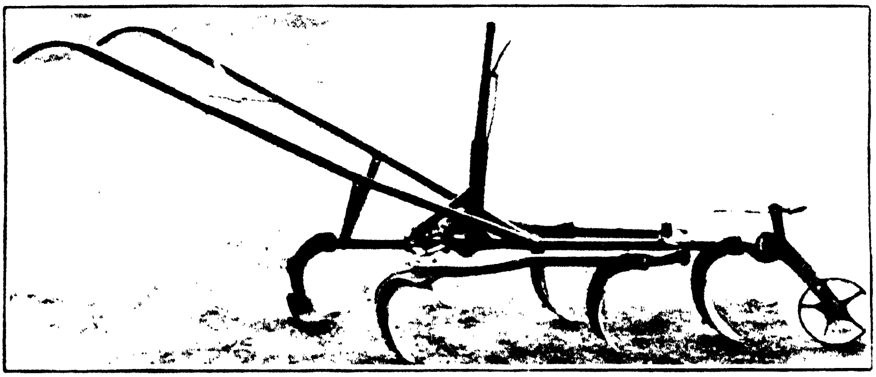


Fig. 2. Horse hoe for turning in the weeds and breaking the surface crust.

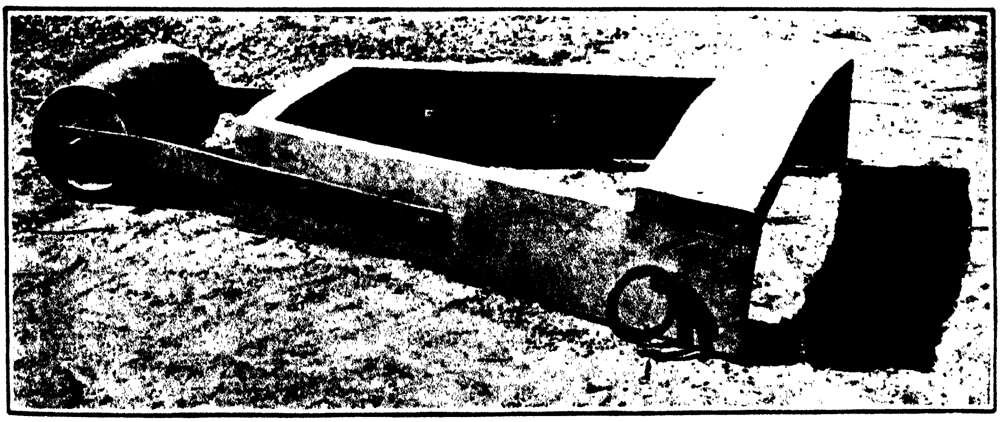


Fig. 3. Gatherer and roller (covers up the furrow with earth after the sets are put in).[1]

Fig. 1. Sets planted eye-to-eye.

Fig. 2. Dressing of concentrated manures. Left—Making hole with the dibble on the ridge. Right—Putting in manure with the spoon and closing the hole with foot.

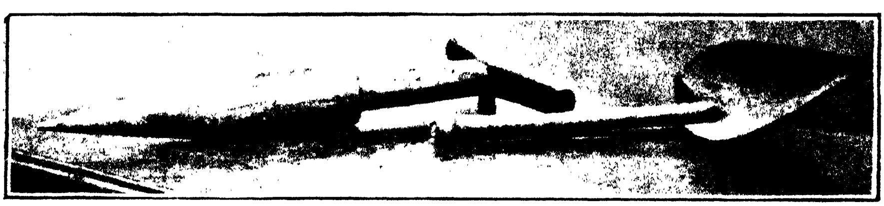


Fig. 3. Dibble and spoon for application of concentrated manures.

the end portion of all furrows, it could be introduced with success in the routine of cane growing in Bihar.

The sets before planting should be soaked in coal tar water which will provide a temporary immunity against white ants to some extent. To make this coal tar mixture, about a gallon of water is boiled with about 10 drops of coal tar added to it (just sufficient to give the water some coal tar smell) and keeping it well stirred. When the mixture is cool, sets are immersed in it and taken out for immediate planting. Care should be taken that no free tar remains in the dipping mixture lest it may injure the cane eyes.

When the sets are placed eye-to-eye and doubled up at the headlands on both sides to a distance of about two yards or so, the gatherer and roller (Plate VI, fig. 3) should be drawn over the furrows, filling them up, covering and pressing the sets. The next thing to be done is the levelling. When one is short planting about the middle of July, for the multiplication of seed-cane of a desirable variety, sets should be planted comparatively shallower, or on the flat, as there is enough moisture then.

MANURING.

It is most desirable that in North Bihar, wherever feasible, green-manuring with sann-hemp and two maunds of superphosphate should be done when sufficient growth of the green crop has taken place and stalks have not become very hard. The land should be left fallow till planting time in February next. At the time of planting, manuring with oil-cake, preferably castor-cake or mustard-cake, at the rate of $\frac{1}{4}$ ton per acre should be given. At the break of the rains and after ridging up, a dressing of either sulphate of ammonia or nitrate of soda at the rate of 2 cwt. per acre will help the young crop to make vigorous growth. If either of these fertilizers be not available, the canes should be dressed with $\frac{1}{4}$ ton cake per acre when ridging up. The method of applying $NaNO_3$ or $(NH_4)_2SO_4$ to unirrigated cane adopted by the Bureau is economical. It consists first in ridging up the young cane, then putting in spoonfuls of the fertilizer with small wooden spoons in holes dibbled on ridges near the stools. The dibbles and spoons used for this work can be made anywhere by a local mistri at a small cost (Plate VII, figs. 2 and 3). When the manure has been dibbled in, the holes are pressed with the foot and closed up. This is the practice followed in Java and it works well here also. The loss of the fertilizer by rainwash is reduced in this way to a minimum.

INTER-CULTIVATION.

In a tract where cane cultivation is carried on without artificial irrigation, it is of the utmost importance to conserve the soil moisture. This requires frequent stirring of the soil in the hot weather to prevent rapid evaporation of soil moisture. The

horse hoe (Plate VI, fig. 2) does this work cheaply and fairly satisfactorily and the present writers consider that it should be more widely taken up.

The ryot's methods of cultivation do not permit of intercultural operations to be carried out. In order that after cultivation may be carried out cheaply with horse hoes working with bullocks it is essential that the system of planting in rows 2½ ft. to 3 ft. apart be adopted in North Bihar and the adjoining districts. The initial cost of a horse hoe is only about Rs. 80, while the charge for hoeing should not exceed Re. 1 to Rs. 1-4 per acre for the season.

ADVANTAGES OF PLANTING IN OCTOBER.

As mentioned above, the canes in Bihar are usually planted in February and are grown without irrigation. If instead, the planting be done after the rains are over in October as soon as the soil conditions permit of cultivation, the temperature conditions and the moisture in the soil being then at their optimum, a much more satisfactory and rapid germination should take place and the plants become established in the soil before the severe cold weather sets in. The young canes would then be enabled to continue their growth in February and March and to withstand the hot weather more successfully. A longer growing season would also be provided. This system of October planting might further prove capable of bringing a larger area under cane cultivation, as light lands which lack sufficient moisture in February and are not able to carry a cane crop successfully, can do so if planted in October. Accordingly, experiments in October planting were started at Pusa and the experience has so far been very encouraging. It is the best time for planting Co. 214 which usually ripens early in November. To keep this cane standing till February for seed purposes has been found detrimental, as sets from over-mature cane planted in February fail to germinate in a number of cases. Planting in October also seems to bring about an earlier maturity in cane, as the following analysis made on the 19th December, 1925, will show :—

Variety of cane	Time of planting	Brix corrected	In juice		Purity
			Sucrose	Glucose	
			Per cent.	Per cent.	
Co. 213	February .	17·34	15·05	0·93	86·77
Ditto	October .	17·66	15·93	0·69	90·21
Co. 205	February .	17·21	14·13	1·16	82·12
Ditto	October .	16·98	14·44	0·87	85·03

This practice has already been adopted by a number of growers who witnessed its practical utility at Pusa.

Co. 210 THE BEST RATOONER.

In Bihar ratooning is practised to some extent, and with the fall in the price of cane the question of ratooning is assuming increasing importance. Experiments were, therefore, made at Pusa to find out the most suitable variety fo. ratooning and the best method of growing a ratoon crop. These have shown that Co. 213 is not a good ratooner. But Co. 210 has been found, taking all points together, to be the best ratooner* of all the improved varieties tested at Pusa. Average yields of ratoon crops obtained at Pusa for the years 1923-24 and 1924-25 were as under :—

Season	Co. 210		Co. 213		Co. 214	
	Acreage	Average yield (stripped) per acre	Acreage	Average yield (stripped) per acre	Acreage	Average yield (stripped) per acre
		Md.		Md.		Md.
1923-24 . .	5·00	390	6· 1	302	10·99	354
1924-25 . .	4·78	430	14·83	376	5·93	314

As regards the treatment of a crop to be kept as ratoon, the plant crop should be got off the field before the end of January or as soon after it as possible. All old stumps should be cut down flush or below ground and followed by ploughing of the land between the cane rows. Next the cane ridges on each side of the cane as close to the clumps as possible should be ploughed out. After that a *henga* (a flat wooden beam) should be drawn over the field to break down all clods, and the middles should be worked to a tilth with a horse-hoe. Patching of all gaps with seed-cane should be done at the usual time of planting. A dressing of oil-cake (¼ to ½ ton per acre) or sulphate of ammonia (1 cwt. to 2 cwt. per acre) should be given at the break of the rains and the crop ridged up.

* **Mr. MacLean, Deputy Director of Agriculture,** North Bihar Range, **wrote in the** Annual **Report of the Sepaya Farm for 1923-24 that the** experiments in ratooning sugarcane **showed that even with careful cultivation during the dry weather and the** application of 3 md. **of** sulphate **of ammonia per acre after the break of** monsoon Hemja on **an** average gave only 235 md. of stripped cane per acre while **Co. 210 in an adjacent area and** with exactly identical treatment gave 560 md. of stripped cane **per acre.**

Measures against diseases of cane.

A cane grower here has generally to reckon with red-rot, smut and mosaic as the principal diseases of cane and with white ants and borers as the worst insect pests. Red-rot can be kept under control by rigid selection of sets when planting. As a rule smut does not cause much damage but the continued growth of a variety, once smut appears in it, is attended with much danger. Early cases of smut are usually found during the hot weather and in the beginning of the rains. Cases will also be noticed when the canes are maturing. As remedial measures it is recommended that all clumps affected by this disease should be dug out as soon as observed, care being taken not to shake them much to avoid spreading of infection. They should then invariably be burnt. Mosaic has been found to be a serious disease in other countries, and Mr. Noel Deerr, the well known sugar technologist, suspected its presence on Hemja and Co. 213 in 1923 and 1924. Co. 210 has so far shown fewer cases of mosaic than Co. 213. Co. 214 has hitherto been found practically free of this disease. The extent of unrecognized overhead loss, if any, due to mosaic in the Coimbatore canes has not yet been determined. The disease is, however, under investigation by the Imperial Mycologist, Pusa. In the meantime, as a measure of control, it is recommended that the mosaic affected clumps should be uprooted and destroyed whenever they are noticed. Taking the planting material from only healthy stools will also help in keeping the disease under control.

Control of insect pests.

White ants are a very serious pest, and it is hardly possible to control them in unirrigated fields. Cane in light soils is more liable to suffer from this pest than that in heavy soils. Where irrigation is available for the germinating canes, the use of a deterrent such as crude oil emulsion has been found to give beneficial results. A man sitting at the head of the main irrigation channel can easily rub the emulsion in running water with his hands. The quantity used should be sufficient to impart a distinct smell of this mixture to the irrigation water. As it is only a palliative, its application is necessary every few days until the canes are well established.

As regards borers, preventive measures require that only sets free from previous borer attack should be planted and that rejected sets should be burnt at once. As the cane stubble harbours a very large number of borers (*Papua depressella*) which hibernate during the cold weather, it is essential that, as soon as the crop is harvested, the stubble should be collected and destroyed effectively. If this is not done, the new crop will be attacked by this pest in the spring when the moths emerge. Ratoon crops are, therefore, to be discouraged where attacks from this borer are severe. The change of planting time has also been reported to have given encouraging results in other parts, and this is as it should be, for if the cane is planted in October the borers will not do any damage to the young shoots as they are then not active, and by the middle of March when the moths emerge the plants will have

already firmly established themselves with the result that they would not then offer such tempting food to the borers.

The experiments with planting of cane in October instead of in February have not been carried out at Pusa over a sufficiently long term of years to enable the writers to say how far this change in the time of planting reduces the attack of borers in this part of India. It is, however, receiving attention both of the Sugar Bureau and the Imperial Entomologist, and it is hoped definite results will be forthcoming in course of time.

It is also necessary to emphasize the importance of rejecting the portion affected by top shoot borers for planting as sets. These canes should be cut off from below the portion where the new shoots have emerged and either fed to cattle or burnt but on no account should they be planted again.

With the systematic and careful selection of healthy sets for planting, clean cultivation, rogueing out of affected plants and employing the measures suggested above for the control of insect pests, it should be possible to grow healthy crops of cane, and continuous propaganda in this direction will do much good in North Bihar.

CONCLUSION.

The recommendations made above are based on the work done at Pusa and are a result of the observations made of prevailing conditions in the surrounding districts. That the methods advocated are practical and can be successfully taken up by the growers with benefit to themselves is borne out by the fact that they are obtaining higher yields by the adoption of these methods. The crop yields per acre at Pusa for the three varieties Co. 210, Co. 213 and Co. 214 for the years 1922-23 to 1925-26 are given below :—

Statement showing the average yield of Coimbatore canes at Pusa.

Season	Co. 210 PLANT		Co. 213 PLANT		Co. 214 PLANT	
	Acreage	Average yield (stripped) per acre	Acreage	Average yield (stripped) per acre	Acreage	Average yield (stripped) per acre
		Md.		Md.		Md.
1922-23 . .	5·00	855	6·01	719	10·99	707
1923-24 . .	4·78	826	17·83	724	5·93	458
1924-25 . .	10·00	690	15·00	611	..	..
1925-26 . .	4·19	476*	6·82	382*	1·00	412*

* The block of land on which the cane crop was grown was very uneven necessitating a good deal of levelling, leaving even then a large number of patches producing a very poor crop growth. The poor quality of the field with its light soil was also responsible for very low yields in 1924-25.

Against these figures may be set down the reports received from some big growers who raised their crop on fairly good cane lands. Only a few cases are cited below :—

(1) *Dowlatpore Concern.* This concern had in the season 1925-26 approximately 450 acres under Coimbatore canes. The yields obtained are given below in the words of Mr. C. Atkins, the Manager, in his letter No. 1083 of 9th April, 1926 : " Yield, Co. 213 irrigated, 820 maunds per acre ; Co. 213 unirrigated, yield per acre 650 maunds ; Co. 210 unirrigated, yield per acre 575 maunds ; Co. 214 unirrigated, 350 maunds per acre."

(2) *Piruckpore Concern.* Mr. Crane, the Manager, in his letter dated the 12th May, 1926, reports the yield of Co. 213 cane as 680½ maunds per acre (unirrigated).

(3) *Barrah Estates, Champaran.* The Manager, in his letter dated 26th April, 1926, intimated that up-to-date the average yield of Co. 210 for the season 1925-26 on an area of 95·75 acres on his estates was 596·73 maunds per acre.

(4) *Manjaul Concern, District Monghyr.* The Manager, in his letter dated the 10th May, 1926, stated that at his branch factories, Sisauni and Bundwar, he got in the season 1925-26 an average yield of 625 maunds and 590 maunds, respectively, per acre of Co. 210.

A fairly large number of sugar factories exist in North Bihar and in the neighbouring district of Gorakhpur. With the fall in the price of sugar, lower payments have to be made to growers for their cane, and as the local Hemja gives poor yields it is hardly able to compete with the more paying crops like tobacco or chillies. Better yielding varieties are therefore required, and, as a result of sustained work, the Sugar Bureau has been successful in popularizing the three improved Coimbatore varieties 210, 213 and 214. These canes, being early ripeners, enable the factories to extend the working season by over a month. Besides this, they are superior to Hemja in stand, vigour, outturn and quality. Both growers and factories realize the importance of these selected cross-bred canes. The former have taken them up with enthusiasm and rendered all assistance in making arrangements for large scale distribution of seed-cane. They are multiplying the seed by short planting, and the area under these canes is expanding every year.

The work in the immediate future in the White Sugar Tract would seem to lie more in widely introducing improvements such as those detailed in this article, keeping the improved canes in the district under close observation and educating the growers in the matter of keeping the cane crops free of disease. At the same time the department should keep itself well stocked with new varieties to replace the present ones, if the latter show signs of degeneration.

ARTIFICIAL HYBRIDIZATION IN RICE.

BY

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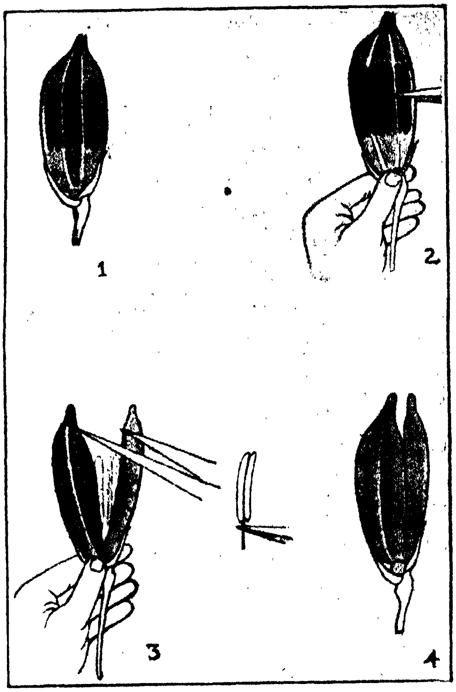
Artificial hybridization being one of the lines of crop improvement, the actual technique of effecting the same in different crops has to be very carefully studied and improved upon by crop specialists. Botanists working on rice in India and elsewhere have evolved their own methods of doing crossing work and are on the look out to improve them. T. P. Torres[1] describes the method adopted in the Philippines, which is also the method followed in Java. It consists in cutting off the top half of the flowering glumes, crosswise, on the previous evening, emasculating them, and pollinating the stigmas inside the next morning. Sarangapani[2] working in Bengal has adopted a method which consists in pulling the two flowering glumes apart, gently holding them at the tip just an hour or two before the natural opening commences, removing the anthers, and tying the glumes with a fine silken thread after the pollination. R. K. Bhide[3] working in Bombay recommends the removal of all the stamens while they are beginning to emerge naturally. It is possible to emasculate and cross-pollinate only a few flowers in a day according to this method, and if it is desired to handle a larger number, he recommends artificial opening of the glumes with the least possible injury to them. He also recommends the growing of the plants to be used in the cross in pots rather than in the field.

The method so far in practice at Coimbatore has been to open the two flowering glumes about two hours previous to the normal time of opening, by inserting a pair of forceps at the end of the spikelet between the glumes, after first unfastening the joint with the tip of the forceps at the sides of the glume. When the two glumes are fairly apart making an angle of about 30 degrees, they are held in that position, and the emasculation is done by removing the anthers, taking care to hold them by the filaments. The emasculated spikelets are kept enclosed in a muslin bag till the pollen of the other parent is ready. The actual pollination is carried out by holding the dehisceing anthers by the forceps over each of the emasculated spikelets, which will have to be opened again, and gently tapping the forceps, when the anthers will shed enough pollen over the stigmas. Enclosing the pollinated spikelets in a cloth bag, though it was in practice in the early years, is not strictly observed now,

[1] *Philippine Agri. Rev.*, XVI, No. 1.
[2] *Agri. Jour. India*, XIX, No. 1.
[3] *Agri. Jour. India*, XX, No. 3.

as it interferes with the proper setting of the grains. One of the officers who has had long practice at this work has attained a high state of efficiency. In varieties where the spikelets are comparatively large, the process is very easy, and even 80 per cent. success has been obtained, though in some cases where the spikelets are comparatively small, it may be as low as 10- 20 per cent. In any case the opening of the glumes has to be done very carefully, and even an experienced man cannot possibly emasculate and pollinate more than 30 to 40 spikelets in a day of 4 to 5 hours. All the methods described above necessitate the handling of the glumes in some way or other, and on account of their extremely delicate nature a certain amount of failure is inevitable.



Emasculation as practised at Coimbatore.

Rice blooming.

The general observations recorded by various workers regarding rice blooming hold good under Coimbatore conditions also. In Coimbatore the number of days taken for all the flowers in a panicle to open in different varieties varies from 5 to 7, the maximum flush—over 50 per cent.—coming on the second and third days. The time of flower-opening in Coimbatore is from 9 A.M. to 12 noon, the intensive flush being recorded after 10 A.M. when the atmospheric temperature is about 82° to 84° F., there being some differences among individual varieties.

Although a certain set of conditions brings about the natural opening of the glumes, the temperature, and probably sun light, plays a very important part. It was shown in a paper prepared for the Science Congress last year that the wild rice *O. latifolia* blooms between 5 to 7 A.M. when the temperature is as low as 72° F. Similarly the wild rice *O. longistaminata* blooms between 12 noon and 2 P.M. when the temperature is about 90° F.—4° to 5° in excess of that required by the cultivated forms. The optimum temperature which must obtain before flowering will commence seems to lie between these two extremes for the cultivated forms. The detailed studies of these two species induced us to try and find out whether different varieties respond to temperature influences in a similar manner.

The following table indicates the temperature range for each of 4 different varieties taken at random, the blooming on the different dates depending on the optimum temperature at the time:—

TABLE I.

Variety	T. 415		E. B. 183		T. 426		P. S. 42	
Date	Blooming time	Temp. at the time	Blooming time	Temp. at the time	Blooming time	Temp. at the time	Blooming time	Temp. at the time
December 1924								
26th .	10-45 A.M.	78° F.	10-30 A.M.	77° F.	10-45 A.M.	78° F.	11-04 A.M.	80° F.
27th . .	11-40 A.M.	78° F.	11-30 A.M.	78° F.	11-00 A.M.	77° F.	11-40 A.M.	78° F.
28th . .	11-10 A.M.	78° F.	11-20 A.M.	78° F.	11-20 A.M.	78° F.	11-10 A.M.	78° F.
			12-20 P.M.	80° F.	12-20 P.M.	80° F.	..	..
29th . .	12-30 P.M.	80° F.	11-50 A.M.	78° F.	12-15 P.M.	79° F.	..	..
30th . .	12-20 P.M.	80° F.	12-20 P.M.	80° F.	12-20 P.M.	80° F.	12-20 P.M.	80° F.
31st . .	11-40 A.M.	79° F.	11-40 A.M.	79° F.	11-40 A.M.	79° F.	11-20 A.M.	78° F.

Among the methods adopted to raise the temperature of the atmosphere surrounding the flower, one was to enclose the panicle in paper bags of different colours. The colours used were black, brown, blue, rose, yellow, brick-red, etc., but the rise of temperature was very rapid in black and brown on account of the greater absorption of heat. The panicles were placed inside the covers early in the morning and the temperature was recorded by a thermometer whose bulb was suspended inside the cover through a small hole at the top. The observations were made through a small catch-door provided on one side of the cover.

Table II indicates the time and temperature in relation to the time of enclosing the earheads in the paper bags. Though the covers were put on early in the morning, the blooming started inside the cover only when the optimum temperature was attained.

TABLE II.

Time of enclosing the panicle	Outside temperature at the time of enclosing	TIME OF BLOOMING INSIDE			TEMPERATURE AT BLOOMING TIME		
		Black cover	Brown cover	Yellow cover	Black cover	Brown cover	Yellow cover
8-30 A.M.	72° F.	8-10	8-15	9-10	86° F.	86° F.	86° F.
9-25 A.M.	76° F.	9-34	9-34	10-40	84° F.	84° F.	85° F.
10-34 A.M.	79° F.	10-40	10-40	10-45	84° F.	84° F.	84° F.
10-45 A.M.	80° F.	..	..	..	..	..	..
General blooming . . .	..	..	..	..	..	..	..

Table III indicates that the two varieties each require a particular temperature for promoting blooming, but they can be induced to open earlier by creating the required temperature by enclosing the panicles in paper covers.

TABLE III.

Colour of the cover used	E. B. 162	TIME OF ENCLOSING 9-34 A.M.		T. 416	TIME OF ENCLOSING 8-44 A.M.	
	Blooming time	Temperature at the time	Outside temperature	Blooming time	Temperature at the time	Outside temperature
Black	9-56	86° F.	78° F.	8-54	86° F.	75° F.
Blue	10-02	84° F.	77° F.	10-20	88° F.	83° F.
Rose	10-20	84° F.	80° F.	10-25	89° F.	83° F.
Yellow	10-14	83° F.	80° F.	10-34	87° F.	86° F.
Brick-red	10-24	84° F.	79° F.	10-19	86° F.	79° F.
General blooming . .	10-56	83° F.	..	10-38	86° F.	..

Attempts were made to increase the humidity in the atmosphere by enclosing the panicle in a wide boiling tube kept inverted, the mouth being plugged with cotton. The ear transpired freely, and drops of water began to form inside the tube and run down the sides, but no such quickening effect was noted as when the panicle was enclosed in paper covers. However, when a roll of black or brown paper was introduced as a lining to the tube, the temperature began to rise and blooming commenced.

In all cases when the glumes were made to open earlier than the natural time by enclosing the panicle in paper covers, the anthers came out without dehiscing at all, the factors governing flower-opening being different from those concerned in the dehiscence of the anthers. This made emasculation very easy and even a beginner could do the crossing work very successfully. This method was adopted on a small scale last year and the seeds obtained were grown this year, and it has been found that more than 80 per cent. of these seeds are crosses. The hastening of the opening of the flowers in the plant to be used as the father, by using the paper cover, is not of any help, as the anthers which come out never dehisce, except in a few special cases.

The following is, then, the method of crossing, using the above principles. A panicle, preferably one that has started flowering the previous day, is selected in the plant to be used as the mother, and all the set spikelets are removed. The panicle is then enclosed in an ordinary brown paper envelope, both the cover and the panicle being held in position by a bamboo stake stuck into the mud by the side of the plant. The enclosing will have to be done just 1 to 1½ hours before the probable time of normal opening which can be foreseen by the prevailing weather conditions. If the cover is removed after 15 to 30 minutes, depending on the degree of sharpness of the sun, all the spikelets which are to open that day are found to have opened in a flush. The anthers are removed at once, and the pollination can be done as soon as the pollen is ready in the plant to be used as the father. After the pollination all the unopened spikelets should also be removed. The method is specially good when a very large number of crosses have to be done, as in the cases of (a) testing the viability of the pollen, and (b) determining the period during which the stigma is receptive.

Since the carrying out of the above experiment last year, a note on "Crossing small grains made easy" has appeared in this Journal.[1] This year some trials were made adopting the method followed by Mr. V. K. Badami in Mysore for *ragi* (*Eleusine coracana*). Rice panicles were enclosed in big glass flasks with strips of wet blotting paper inside, just an hour before the normal time of opening, as was done in the case of the paper covers. Though the anthers were found to have come out undehisced, the flower opening did not start earlier than the normal opening outside. Moreover, when the flask was removed, the anthers began to dehisce immediately,

[1] *Agri. Jour. India*, XX, No. 3.

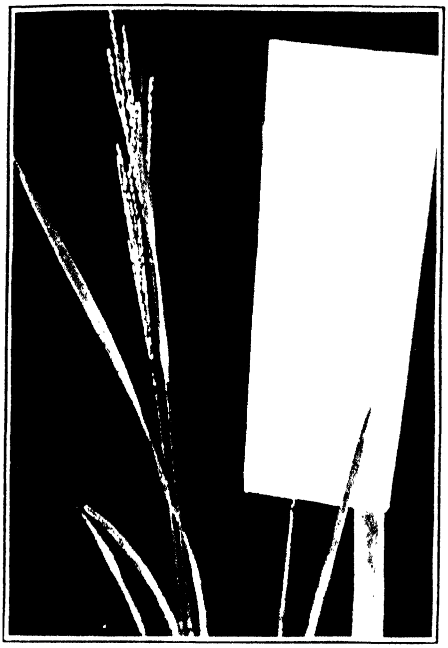
hardly allowing time for emasculation. But if the flask was covered outside with a brown paper, flower opening was noticed to commence much earlier as in the case of the ordinary paper bag. Putting the flask over the panicle the previous evening as was done in the case of *ragi*, was not of any help either. In the case of the wild rice *O. latifolia*, which starts opening very early in the morning as *ragi* does, the flask was found to work efficiently.

The cutting of a few earheads and keeping them in a jar of water to give pollen for the crossing work, as adopted by Mr. V. K. Badami, is found to be applicable in the case of paddy also, but only to a limited extent, since all varieties do not respond equally to this treatment. Here again the flowers do not open if the cut panicles are left in the sun; they have to be moved to the shade inside a building. In varieties where the dehiscence is all right, the crossing work is certainly greatly simplified, as the pollen is ready immediately the emasculation is finished.

Explanation of Plate VIII.

Artificial hybridization of rice.

1. Rice plant showing paper cover in position over one panicle.
2. Same panicle after removal of paper cover.
3. Portion of the same panicle, to show free emergence of anthers.
4. Spikelets after emasculation. Unopened spikelets removed.
5. Portion of panicle of awned variety, to show anther emergence after removal of paper cover.



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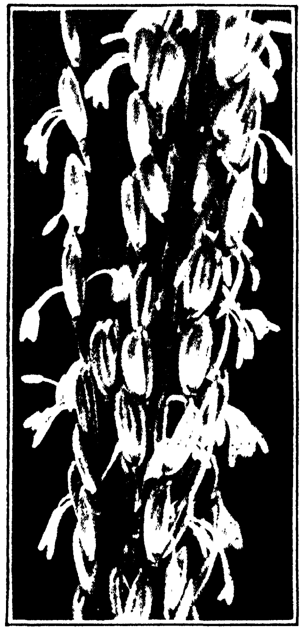

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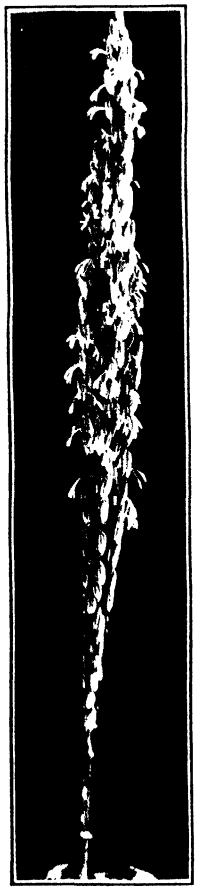

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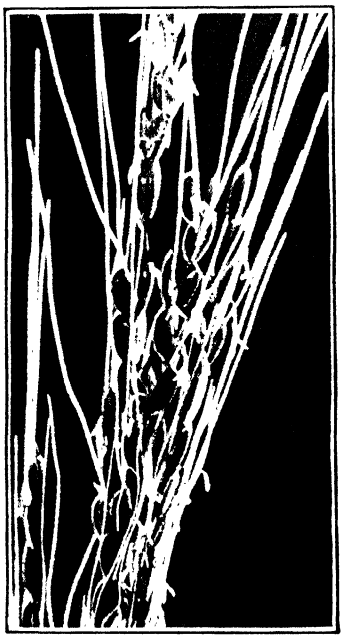

5

VARIABILITY IN THE GINNING PERCENTAGES IN CROSSES OF INDIAN COTTONS.

BY

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WITH a view to evolve a plant possessing a fairly long staple and high ginning percentage, and capable of fitting into the climatic conditions of the United Provinces, numerous crosses were made between the various types of cotton at the Botanical Research Farm, Cawnpore. All the available material to build up such a plant was explored, and in order to attain the aforesaid object, a number of lines were started, including a series in which crosses between *Gossypium arboreum* and *Gossypium neglectum roseum* were made. *Gossypium arboreum* is an almost perennial cotton, and yields fibre about one inch in length, but gins at a low figure of about 25 per cent. The second parent, *Gossypium neglectum roseum*, on the other hand, possesses a fibre which is ordinarily about ⅜ inch in length but has a ginning percentage much higher, frequently reaching up to 39 and 40. The former is a very late and the latter comparatively an early flowering cotton. Different vegetative characters and their inheritance in subsequent generations after the F_1 have already been dealt with elsewhere.[1] The present article is intended to describe only the variations in ginning percentages which were observed and recorded in the course of an investigation carried on with this cross for a number of years.

The cross was originally made by Dr. Leake about 20 years ago, and after making a preliminary study of its various aspects for about five years, it was in 1911 that a plant with a ginning percentage of 31 and good length attracted attention for its fertility and other agricultural characters. In length of fibre and general adaptability which this particular individual possessed, it appeared quite satisfactory, but still considerably lagged behind in ginning percentage. Efforts were made to improve this feature by further multiplying it and raising a large number of plants and selecting the best ginning ones from year to year. The process presented results which were encouraging every season. It was very interesting to find the gradual rise

[1] Leake H. M., and Rama Prasada. Studies in Indian Cottons: Vegetative Characters. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. VI, No. 4.

which took place in ginning percentage as the work progressed. In addition to the individuals which were selected for separate determinations every year, the remaining plants of each single plant culture were also collectively picked and their combined ginning percentage was ascertained. Differences were found in the averages of separately determined plants and the combined lots, but generally they are such as are consistent with the normal phases of variation. The results thus obtained are shown in Table I on page 25.

The figures in antique indicate the average mean of all the single plants determined in that year. From 1912 when the plants averaged at the value of 30 ginning percentage there was a continuous and steady rise in the average till it touched 38 in 1917. A drop of 2 per cent. was observed in 1918 when the average reverted to 36 per cent. The series was carried on for one more year but on getting the same average in 1919 it was discontinued.

It should also be mentioned here that the averages were calculated on the selected single plants of the series raised in a particular season, and the remainder sister plants of the different single plant cultures raised were all amalgamated to arrive at the general average for the year. Figures thus obtained, along with the number of the single plant cultures raised, are given in the last column of the table.

In one case, however, it was felt desirable to select one plant with a certain ginning value, collect all its seeds, sow them individually and determine the ginning percentage of *all the plant separately* and see whether the average thus obtained agreed with the figure of the parent of the progeny so determined. This was carried on for three years. The figures are given in Table II on page 26.

It is obvious that the produce of a single plant gives individuals which on an average do not reach the level of their parent in this case. In the following year a plant from the progeny which had the same ginning percentage of 39 was again selfed and similarly grown and treated. The results show a further drop of 2 per cent. The series was continued for one more year and the results were found almost the same as in the preceding year.

In 1915 when the cross was in its F_{10} generation, a plant from it ginning 30 per cent. was crossed with *Gossypium cerneuum* Tod. which possesses the highest ginning percentage known in Indian cottons so far. The plant actually used in crossing as the pollen parent ginned 45 per cent. Its subsequent generations are shown in the chart on page 27. It will be observed in this case that the offspring have maintained on an average a high level of ginning values for seven years.

In following the results given above from year to year it was felt that considering the number of plants handled for each culture, comparatively very few were taken for calculating the ginning percentage. If the values for the remaining plants were also determined they might possibly reveal further variations. In order to be satisfied on this point a parallel series of plants was raised separately and examined more closely.

TABLE I.

Showing the ginning percentages of a cross between Gossypium arboreum and Gossypium neglectum roseum.

Year	Generation	Number of individual plants on which ginning percentage was determined	Ginning percentage																				Average of individual plant determinations	Total number of single plant cultures raised	Averages of ginning percentages of single plant cultures
			25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44			
1911	F_6	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	31·5	..	..
1912	F_7	20	1	..	2	..	8	5	2	1	..	..	1	..	..	..	..	..	..	..	..	..	29·5	..	..
1913	F_8	36	..	..	2	1	..	3	5	4	7	9	1	2	..	2	..	..	..	..	..	..	32·6	20	29·6
1914	F_9	99	..	..	2	4	4	5	4	9	8	5	13	14	16	11	3	1	..	..	..	..	34·4	11	33·9
1915	F_{10}	662	..	..	..	5	10	10	14	52	105	92	125	94	78	66	20	7	4	..	..	..	34·9	50	36·1
1916	F_{11}	290	1	1	1	..	..	..	2	4	11	12	29	25	10	55	47	28	17	19	6	1	37·4	193	37·2
1917	F_{12}	121	..	..	..	..	..	..	..	..	..	8	9	11	34	23	16	[illegible]	5	1	..	..	37·6	100	38·7
1918	F_{13}	440	..	..	..	..	..	..	..	3	7	20	92	122	115	51	16	6	2	..	..	..	36·2	102	35·3
1919	F_{14}	295	..	..	..	..	..	..	2	3	7	8	36	71	71	30	9	5	2	1	..	..	36·3	254	37·7

TABLE II.

Showing ginning percentages of an individual plant all the progeny of which were determined for three years.

Year	Generation	Number of individual plants on which ginning percentage was determined	GINNING PERCENTAGES OF OFF-SPRING													Average of individual plant determination	Ginning percentage of parent
			30	31	32	33	34	35	36	37	38	39	40	41	42		
1916 .	F_{11} .	1	..	..	..	..	.	..	..	..	..	1	..	..	..	39	..
1917 .	F_{12} .	72	..	..	1	4	6	7	8	21	14	9	2	..	..	36·6	39
1918 .	F_{13} .	68	..	..	..	2	4	19	18	21	4	..	..	..	..	35·9	39
1919 .	F_{14} .	36	..	1	1	1	3	11	6	5	8	..	..	..	..	35·7	..

*Chart showing ginning percentages of selected plants of Gossypium arboreum × Go sypium neglectum roseum × Gossypium cerneuum for seven generations. (Parents ginning percentages 32 × **45**).*

Year	Generation	Ginning percentages determined on number of plants	Average
1916 . . .	F_1 . .	1: 43; 2: 34; 3: 45; 4: 42	41
1917 . . .	F_2 . .	1: 40; 2: 38; 3: 36; 4: 40; 5: 39; 6: 38	38·5
1918 . . .	F_3 . .	1: 36; 2: 32; 3: 40; 4: 37; 5: 38; 6: 37; 7: 40; 8: 35	36·9
1919 . . .	F_4 . .	1: 39; 2: 38; 3: 37·5; 4: 39·5	38·5
1920 . . .	F_5 . .	1: 37·5; 2: 37·5; 3: 38·5; 4: 40·5; 5: 40; 6: 42; 7: 40	39·5
1921 . . .	F_6 . .	1: 36; 2: 34; 3: 42; 4: 44; 5: 43; 6: 40; 7: 42; 8: 43; 9: 40; 10: 43; 11: 42	41
1922 . . .	F_7 . .	1: 36; 2: 42; 3: 43; 4: 42; 5: 44; 6: 44; 7: 40; 8: 40; 9: 41	41

TABLE III.

Showing ginning percentage of all plants raised from the selfed single plant cultures of Gossypium arboreum × Gossypium neglectum roseum × Gossypium cerneuum.

Year	Generation	Number of individual plants of which ginning percentage was determined	Ginning percentages of off-spring: 23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Averages of ginning percentages of individual plant determination	Ginning percentage value of the parent
1919	F_4	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	37·7	..
1920	F_5	31	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	3	6	12	2	3	1	1	..	..	..	..	39·8	38
1921	F_6	(a)27	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	2	2	5	1	5	3	1	..	1	1	..	40·5	40
		(b)34	..	1	..	1	..	..	2	4	2	1	8	..	..	2	1	3	4	4	1	..	..	..	..	..	..	..	34·3	40
		(c)52	..	..	..	..	1	..	..	..	..	1	2	3	11	8	10	6	6	3	..	1	..	..	..	..	..	..	36·4	40
		(d)50	..	..	..	..	..	..	..	2	2	2	7	2	8	4	9	6	1	6	1	..	..	..	..	..	..	..	35·6	41
		(e)41	..	..	..	..	..	..	..	..	1	..	3	..	3	4	5	6	3	8	4	3	1	..	..	..	..	..	38·0	42
1922	F_7	120	..	..	..	..	..	..	..	..	..	..	..	1	2	17	27	29	18	14	7	5	..	..	..	..	..	..	38·1	..

(a) to (e) single plant cultures of sister plants.

When this *cerneuum* cross was in its F_4 generation in 1919, cotton from all the remaining plants, excluding the 4 individuals separately determined, was gathered collectively and the ginning percentage for this combined sample was ascertained and found to be 37·7 per cent. In the following year in 1920 the seeds from this combined lot were grown and 31 individual plants, without any previous reference to their ginning history, were selected at random and bagged to protect their purity. They were separately picked and their ginning values averaged 39·8 in their F_5 generation. From this lot 5 plants ginning 40 per cent. and above were selected and *all* the available seeds from these five were grown and selfed. The produce of these selfed plants was individually collected and the ginning percentage for *each plant* was calculated separately. Figures for all the series so raised are given in Table III on page 28.

In Table II we have seen that there is a drop of about 2 per cent. when all the plants of a single plant culture are individually collected for their ginning percentages. Here we find the figures quite interesting from the variation point of view. The single plant from which the whole series was multiplied had 37·7 per cent. in its F_3 in 1918 as Table III shows. The seed parent and the pollen parent composing the original cross in 1915 had 32 and 45 ginning percentages respectively. Besides exposing the instability of some of its progeny in F_6, the plants of this cross also appear to have exceeded the extreme limits of the values characterizing the original parents. One plant ginned 24, while the other 47 per cent. The offspring of one of the parents with a ginning percentage of 40 averaged 34·3 per cent. only.

The above mentioned facts create some disappointment with regard to the hope of ultimate success in purifying and fixing a strain with high ginning percentage. But this is not, however, the case in practice. By gradual steering of the high ginning values from year to year strains have been isolated which on an average gin much higher than their original parents. Table I has already illustrated this point in the beginning. The range of variation is extensive but if the desirable values are selected with persistence, the labour involved in selecting, selfing, picking and ginning plants individually and carrying them in this manner from year to year is sure to be justified and is expected to bring forth the result aimed at.

THE NEED FOR THE DEVELOPMENT OF DAIRYING AS A VILLAGE INDUSTRY AND SOME OF THE PROBABLE RESULTS.*

BY

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ZEMINDARS and cultivators who undertake cattle-breeding and stock-raising in this country usually consider it a business subsidiary to the more profitable business of food grain production. In consequence all land that can be profitably cultivated for food grain production is usually so utilized, the cattle of the country being maintained chiefly on the byproducts of food grain crops such as *bhusa* (straw-chaff), *chari* (dry sorghum stalks) and on such grazing as bare fallows and land which is never cultivated can produce.

In spite of the frequency of periods of severe fodder shortage, and the cattle losses which such periods cause, the cultivation of land for fodder crops to serve the sole purpose of fodder for cattle is limited to very small areas which are practically negligible when compared with the total area under cultivation.

In those parts of India where there are large areas of uncultivated land large herds of cattle are usually raised. The type of animal so raised varies with the local conditions. Where these are favourable as in the Punjab and Rajputana States some good cattle are to be found ; under unfavourable conditions such as prevail in the *terai* tracts of the United Provinces, Bihar and Bengal cattle of inferior type are the rule. It is unfortunate that it is usually those parts which climatically are the most favourable for cattle, namely, the drier tracts, that are the most liable to suffer from periods of fodder shortage, repetitions of which form a very serious obstacle to progressive breeding and improvement of type.

Like all other animals cattle require a regular supply of suitable food nutrients for their proper maintenance. The majority of cattle of India do not get throughout the growing and productive periods of their lives a regular and adequate supply. The grazing grounds on which the majority are raised produce a sufficiency of grass for a few months of the year only, and every year during the dry and hot weather

* Paper read at the Indian Science Congress, Bombay, 1926.

cattle not only subsist on a short supply but on a short supply of inferior feeding value. Deficient monsoons in some of our best cattle-breeding tracts often result in whole years of fodder shortage.

Years of these conditions assisted by other circumstances have given rise to cattle of considerable hardiness but which for the most part are very poor breeders and poor milk producers, which very qualities operate largely to make cattle-breeding a business of small profit.

The questions which first come to the minds of those interested in cattle-breeding and cattle improvement are, " Can the effects of fodder famine years and these seasons of fodder shortage be minimized "? " Can cattle-breeding not be carried on under conditions which will guarantee a regular supply of fodder"?

A regular supply of fodder can be produced only by the use of cultivated land and by the production of fodder in large quantities in suitable seasons for storage against periods of scarcity. Cultivated land, however, can be put to this use only when the production of fodder can be made as profitable as the production of food grain crops.

The income derivable from fodder production is not direct but is derived from the sale of cattle and dairy products.

The average cattle-owner when calculating the probable income from his cattle-breeding can include such items as the sale of young male stock and dairy products, the chief being the sale of *ghi* (clarified butter). With regard to th receipts for sale of young stock it is probable that the breeder generally derives a price more or less commensurate with their market value, provided the market is not at the time flooded with cattle on account of a fodder shortage being imminent.

With regard to the dairy produce the case appears somewhat different. In spite of the fact that most cities suffer from a shortage of milk and that the city price of whole milk is often double the price of similar milk in a village ten miles distant, only an infinitesimally small portion of the milk produced finds its way as such into city markets; practically the whole of the milk produced in villages which is marketed outside the village is sold in the form of *ghi*.

In the United Provinces the average village price for pure milk is eight or more seers per rupee and the city price 4 seers per rupee. It is not known how much village milk the cities are capable of consuming or how much of the milk which is now converted into *ghi* at the rate of 8 seers per rupee would find a market to city consumers at 4 seers per rupee. The demand is without doubt large, and by the organization of a purer supply this demand might possibly be further increased. Be this as it may, it is certain that there is a better market open for a considerable quantity of milk, which, owing to the absence of transport facilities and suitable purchasing and distributing agencies, is within the reach of a very small number of villages, namely, those closely situated to the town market. The margin of difference between the average village price of 8 seers per rupee and the city price of 4 seers per rupee seems large enough to provide opportunities to collecting and

distributing agencies to develop a town milk supply similar to that existing in other countries where more up-to-date dairy practices are in vogue.

The benefit of such development to city consumers is obvious. This note is concerned with the possible effect on the practices of village cattle-owners and cattle-breeders.

In a village in a canal-irrigated tract in the Agra District eight miles from the Agra city, where an attempt has been made at organized village milk collection, it has been found that where, previous to the inception of the scheme, the whole of the milk produced in the village was converted into *ghi*, practically the whole of the milk now produced in the village, an average of 10 maunds daily, is now sold as whole milk at a rate varying from 7-8 seers per rupee to the collecting agency for sale in the Agra city market. Last year from the single village which has on an average an area of 450 acres under *rabi* cultivation the outturn of milk for direct consumption when valued at 8 seers per rupee equalled in value to half the total *rabi* crop of the village.

The business now admits of expansion and other neighbouring villages are being drawn upon. The middleman who operates the scheme is an enterprising zemindar with an Agricultural College training. The scheme has been handicapped for want of capital, but this year Government have provided a small grant for the establishment of a dairy equipped with a small pasteurizing plant, which, it is hoped, will make it possible to draw upon all other villages within a radius of 5 miles of the central village in which the dairy and pasteurizing plant are established.

In most villages in the Agra District there are a number of good cows capable of giving a fair quantity of milk. This number, however, is not sufficient to produce 9-10 maunds of milk daily from a single village. The promoter of the scheme, however, by giving advances for the purchase of good cows and buffaloes, was soon able to secure the amount of milk required. Repayment of the advances being made in the form of milk, the debt incurred did not become a burden : in fact it was hardly felt by the villagers taking the loan. The promoter at the same time set aside as much of his own loan as possible for fodder cultivation during the *kharif* and for oats during the *rabi*, and has stored a considerable amount of fodder annually in the central village for sale at periods of scarcity to the village-milk-producers. The provision of cheap fodder for the cattle and the provision of capital for the purchase of good cows guarantee him the required amount of milk to meet the requirements of the city market. The villagers have realized the need of good cows and the necessity for improving their herds, and Government stud bulls have been located there.

The view is occasionally expressed that much improvement in the milking capacity of Indian cows is needed before the dairy industry can be developed to meet the requirements of city consumers and before milk production can be made a profitable business. If the neceesary milk is to be produced on large dairy farms as understood in other countries and as usually suggested for municipal dairy schemes,

I think this view is correct; but in villages milk is produced so economically and at so low a cost that with good average cattle such as are available in the main cattle-breeding tract of Northern India, it is possible, as the above cited case shows, to stimulate a considerable scale of production, provided a ready market is available. The business is one which is likely to prove very attractive to cultivators. The labour of attending to the cattle can be undertaken by their families and the regular return of cash which daily sales provide is a very strong inducement. This regular daily return throughout the year gives the villagers considerable security, since milk production as a business is less likely to be immediately affected by the vagaries of the season than cereal crop production. The climate of India to a large extent lends itself to the production of useful heavy yielding fodder crops, and a heavy yield of fodder can be grown at low cost. If a ready market were provided for milk produced in villages where fodder crops can be readily grown, a means would be provided of converting fodder into a saleable and marketable commodity, and consequently the area of cultivated fodder crops would rapidly extend to provide the necessary fodder to produce the supply of milk to meet the demand of the market.

The introduction of fodder crop cultivation into village agricultural practice does not necessarily mean that land will be diverted from food crop production for this purpose. The land lying immediately around villages is capable of giving very heavy yields of fodder and often at periods when they are otherwise lying out of cultivation, and very small areas of such land are required to yield the necessary supply. At present the cultivator requires to grow fodder for his bullocks and usually such provision is made. There is no profit in growing fodder specially for purely breeding stock and consequently very little is set aside for this purpose. The development of collecting agencies to provide a market for village milk will make fodder growing for milking cows and breeding stock profitable, and when this is the case the necessary amount will be forthcoming. Mixed farming has its virtues in countries more favoured with seasons suited to the requirements of agriculture than India. Its development in this country where season can be so unfavourable as to bring crop production except in irrigated tracts practically to a standstill, and where agriculture draws its power for cultivation from cattle, seems an absolute necessity. There seems no doubt that the provision of facilities for the proper transport of milk to enable a better market for milk to be put at the service of the village producer is the first step to the introduction of mixed farming practices and the consequent improvement in the condition of cattle husbandry.

PRELIMINARY NOTE ON AN INTERNAL BOLL DISEASE OF COTTON IN BURMA.

BY

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During the early part of November 1925 the writer's attention was drawn to an internal disease of unripe cotton bolls caused by two species of *Nematospora,* in which a yellow or brown discoloration of the lint succeeded by rotting of the whole contents of the fruits was manifest. The rot was in many cases accompanied by boll-worm attack. An examination of a large number of immature bolls showed boll-worm infection to be present in about 30 per cent. on all varieties of cotton, whilst the rotting occurred up to 100 per cent. in some cases. The following percentages of rotting not due to boll-worms were found :—

TABLE I.

Date	Variety	Locality	Percentage of rotting
13th November 1925	Wagyi	Mandalay Farm	43
15th December 1925	Cambodia	Padu Farm	50
Do.	Padu Wagale	Do.	71·4
16th December 1925	Cambodia	Tatkon Farm	93·3
17th December 1925	Do.	Kyehmon	87·5
20th December 1925	Do.	Mandalay Farm	90
10th January 1926	Do.	Tatkon Farm	100

The disease was found in every cotton field examined, including the Mahlaing and Allanmyo Government Farms.

It appears that the Burmese types Wagale and Wagyi are less attacked than the American variety Cambodia ; further, the disease increases as the season advances up to the end of January, after which time it decreases. The Kyehmon Cambodia area which showed 87·5 per cent. infection in the middle of December was almost free from the disease by the middle of March. This periodicity corresponds with

an increase and decrease in the number of red bugs, *Dysdercus cingulatus*, A., on cotton plants.

Diseased bolls show no external symptoms whatever, but appear normally green and healthy. On cutting them open the contents are found to be decayed, the lint being stained yellow or brown, with occasionally a pinkish tinge. The inner surface of the wall invariably shows signs of having been punctured by insects; frequently there is proliferation of the tissues of the wall inside to form a small wart at the site of the injury. In the early stages infection has been always found to have originated at one or more of these punctures, a small patch of yellow-coloured lint being seen immediately adjacent to the puncture. The insect responsible for the puncturing is the red bug, *Dysdercus cingulatus*, A., which occurs in great numbers on cotton and other plants in Burma from October to the end of January. In February and March it occurs only in small numbers on cotton.

Microscopical examination of the discoloured lint revealed the presence of *Nematospora* in 99 per cent. of the cases and of bacteria only in one per cent.

A number of fungi belonging to the genus *Nematospora* have been described from time to time on fruits of various kinds. The genus was founded by Peglion in 1901 with one species, *Nematospora Coryli*, Pegl., on diseased fruits of *Corylus Avellana* in Italy.[1] Since then a number of workers in various parts of the world have recorded other species, all on fruits, and all closely resembling the original type species.

Two species causing an internal boll disease of cotton have been described by Nowell[2] from Trinidad and the two Burmese fungi correspond very closely with Nowell's species. The commonest form is species C. This has a distinct mycelium; the spores are found in two bundles of four connected by a fine filament on terminal or intercalary sporangia. The spore measurements are 28·5-43 μ long by 2-3 μ broad, the measurement given by Nowell being 27-35 × 2 μ. Except for the slightly larger spores the organism appears to fit the description given by Nowell.

The second less common species corresponds equally closely with Nowell's species D, the spore measurements in this case being 25-43 × 1·5-3 μ for the Burmese fungus and 30-40 × 2-3 μ for Nowell's.

Species C was first met with and all inoculations were carried out with it. Species D was not found till late in the season when it was too late to do any work with it.

Inoculations carried out with pure cultures of the fungus (species C) were not entirely successful owing to a number of the bolls being destroyed by boll-worms. Table II shows the results obtained by injecting a suspension of spores in sterile

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[1] Peglion, V. Ueber die *Nematospora Coryli* Pegl. *Centr. f. Bakt. II abt.*, Vol. VII, p. 754, 1901.

[2] Nowell, W. Internal disease of cotton bolls in the West Indies. *West Indian Bull.*, XVI, p. 203, 1917.

Nowell, W. The fungi of internal boll disease. *West Indian Bull.*, XVI, p. 152, 1917.

distilled water into unripe bolls with a hypodermic syringe. The plants had been kept under mosquito netting for five weeks to exclude insects as far as possible and the bolls inoculated had developed during that period.

TABLE II.

Date of inoculation	Date examined	No. of days	Results
5th February 1926 . .	12th February 1926 . .	7	Contents rotten and yellow. *Nematospora* present.
Do. . .	Do. . .	7	Slight rotting. *Nematospora* present. Proliferation of wall of locules at site of inoculation.
10th February 1926 . .	2nd March 1926 . .	20	Completely rotten. *Nematospora* present.
Do . .	Do. . .	20	Do. do.

Four controls inoculated with sterile distilled water showed no rotting after 25 days. Seven other hypodermic inoculations were carried out but the bolls were destroyed by boll-worms.

Inoculations were then carried out with red bugs which had been fed on diseased bolls. The plants were enclosed in mosquito nets (one set) and muslin (one set) with two sets of controls. A number of bugs were then placed in the cages and allowed to feed for 32 days, after which the bolls were removed and examined.

The results are given below in Tables III and IV.

TABLE III.

Cotton boll inoculations with red bugs under muslin nets.

No. of boll	Insect punctures	*Nematospora* Species C	Condition of contents of boll.
1 . .	+	+	Slight yellow staining of lint.
2 . .	+	+	Ditto.
3 .	—	—	Healthy.
4 . .	+	+	Slight decay.
5 . .	—	—	Healthy.
6 . .	+	+	Slight rotting.
7 . .	—	—	Healthy.
8 . .	+	+	Boll-worms also present. Decayed.
9 . .	+	—	Bacteria present in one loculus.

TABLE III—*concld.*

Cotton boll inoculations with red bugs under muslin nets—concld.

No. of boll	Insect punctures	*Nematospora* Species C	Condition of contents of boll
10 . .	+	+	Decayed.
11 . .	+	+	Decayed.
12 . .	+	+	Completely rotted.
13 . .	+	+	Punctured in one loculus only. *Nematospora* and decay in punctured loculus.
14 . .	+	+	Slight decay.
15 . .	+	+	Do.
16 . .	+	+	Do.
17 . .	—	—	Healthy.
18 . .	+	+	Decayed.
19 . .	+	+	Do.
20 . .	+	+	Do.
21 . .	+	+	Do.
22 . .	—	—	Healthy.
23 . .	+	+	Completely decayed.
24 . .	+	+	Do.

TABLE IV.

Cotton boll inoculations with red bugs under mosquito nets.

No. of boll	Insect punctures	*Nematospora* Species C	Condition of contents of boll
1 . .	+	+	Decayed.
2 . .	+	+	Do.
3 . .	+	+	Do.
4 . .	+	+	Do.
5 . .	+	+	Do.
6 . .	+	+	Do.
7 . .	+	+	Do.

TABLE IV—*concld.*

Cotton boll inoculations with red bugs under mosquito nets—concld.

No. of boll	Insect punctures	*Nematospora* Species C	Condition of contents of boll
8 . .	—	—	Healthy.
9 . .	+	+	Completely rotten.
10 . .	—	—	Healthy.
11 . .	—	—	Do.
12 . .	+	+	Decayed.
13 . .	+	+	Do.
14 . .	+	—	Healthy.

Controls kept under muslin and musquito nets without red bugs remained healthy in every case.

It will be seen from Table III that out of a total of 24 bolls 19 had been punctured by the insect and in 18 of these punctured bolls the fungus was found. On every occasion when *Nematospora* was present in the boll the contents were decayed. Table IV shows a similar result with cotton bolls kept under mosquito netting. Out of 11 bolls punctured 10 were infected with *Nematospora* and decayed.

From a consideration of these results it is evident that the bug *Dysdercus cingulatus* is intimately connected with the spread of the disease. Owing to the lateness of the season when the disease was discovered it was not found possible to experiment with bugs which had not fed on diseased bolls, and therefore it is not possible to say whether the bugs actually convey the fungus or whether the latter gains entrance through the punctures made by the bugs. Attempts to cause infection by pricking the bolls with sterile needles and placing spores of the fungus on the outside of the bolls in various ways failed in every case. From a consideration of the dimensions of the spores and of the mouth-parts of the insect it does not seem likely that the fungus can be carried in any way except on the outside of the mandibles. It is possible for the spores to enter the suction canal, but only just possible. Infection may, however, be brought about by one of the small yeast-like forms of the fungus (D) and not by the large flagellated spores.

The disease is certainly the most serious cotton disease in Burma. It is not possible to give any estimate of the financial loss caused by it, but it may be mentioned that it seems likely to render the cultivation of the highly susceptible Cambodia type unprofitable.

The writer is indebted to Mr. C. C. Ghosh, B.A., Entomologist, for assistance in connection with the handling of the insects and for much useful information concerning their feeding habits.

THE ERADICATION OF KANS (*SACCHARUM SPONTANEUM* L.).*

BY

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Director, Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India.

One of the chief obstacles to the growth of cotton and other crops in Central India, Bundelkhand and parts of the Central Provinces is a perennial deep-rooted grass known as *kans* (*Saccharum spontaneum* L.). At a conservative estimate the reduction in the yield of cotton caused by this weed is at least a third of the crop. The implements at the disposal of the cultivator only serve to keep *kans* in check: they do not eradicate it. Attempts are now being made in some parts of India to bring this pest under control by means of tractors but the method is expensive and not very suitable for the ordinary villager.

As more than half the three hundred acres leased to the Institute of Plant Industry were infested with *kans* and quite unfit for experimental work, the eradication of this weed was at once taken up. The funds available were insufficient either to consider the purchase of a tractor or to adopt the local method of digging out the weed by hand which costs about eighty rupees an acre. Some cheaper method therefore had to be devised.

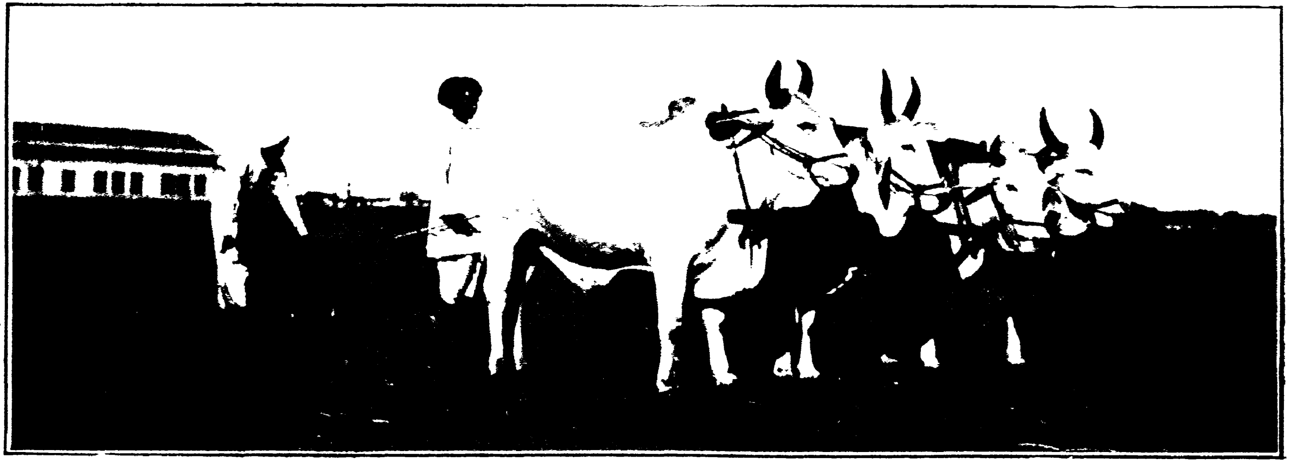
The first attempts were made with heavy soil-inverting ploughs——Ransomes' steel-bar plough and the C. T. plough were tried, each drawn by two pairs of oxen in the usual manner. The results were unsatisfactory and the amount of work done each day was small. The failure of these ploughs was partly due to the great force needed to turn a deep furrow, and partly to the fact that when two separate pairs of oxen are yoked to the same plough there is a good deal of non-co-operation and the animals only occasionally pull together. A little consideration of the problem soon led to the conclusion that furrow-inversion —— so essential in the damp soils of the Occident for killing weeds by cutting off the light——is quite unnecessary in India where the sun does the same work for nothing once the weeds are loosened or uprooted. Soil-inversion, besides requiring a large amount of draught, interferes with levels and is particularly harmful on black soils after the rains by producing large clods which prevent the work cattle from walking on the cultivated surface.

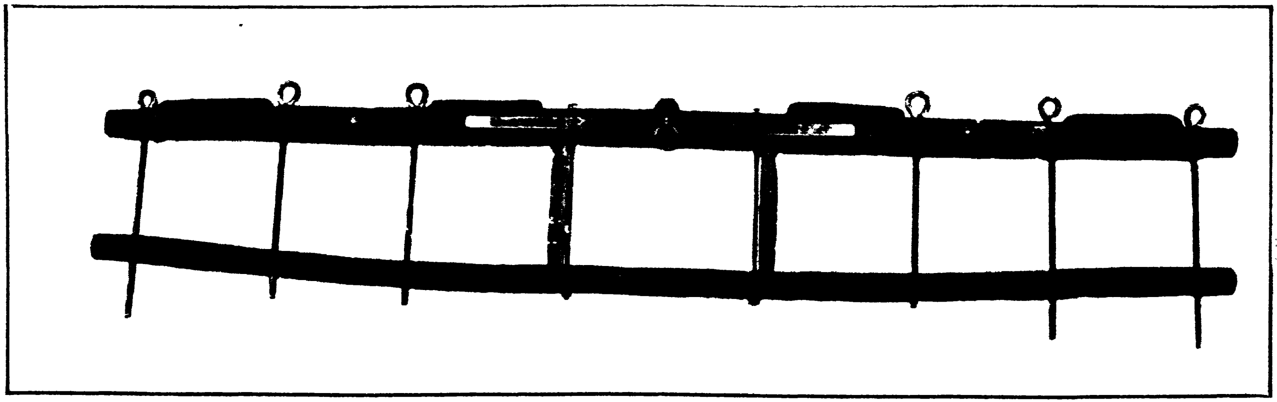
* Paper read before the Agricultural Section of the Indian Science Congress, Lahore, January 1927

These difficulties were overcome by the use of an adjustable *bakhar* capable of working to a depth of 8 to 9 inches drawn by two pairs of oxen *walking abreast*. This *bakhar* was obtained by dismantling and slightly altering the P. & O. 10 inch ridging plough manufactured by the International Harvester Company and on sale in India at forty rupees. The broad share of this plough, when the wings and sole are removed, acts as a very efficient and self-cleaning *bakhar* blade and uproots the dense mass of *kans* rhizomes which run mostly in the upper eight inches of soil. The depth of working is adjusted by the front wheel. The yoke is attached to the sub-soiler by a strong chain of suitable length, so arranged that the line of draught passes through the centre of resistance of the share. The draught is supplied by four oxen walking abreast provided with a long yoke, nine feet four inches long by one foot seven inches deep, fitted with iron pins which prevent the oxen getting off the yoke when turning. Under this system non-co-operation disappears, the animals work together and exert their maximum power. The arrangement will be clear on referring to Plate IX. One of these sub-soilers will plough an acre of land a day at a cost somewhat below five rupees. This adjustable *bakhar* is proving very effective in *kans* eradication at Indore and this adverse factor is rapidly being eliminated. Plots infected with *kans* in September 1925 were fit for cotton cultures by June 1926. The most effective periods for dealing with this pest appear to be during the time of active growth in the rains or at the beginning of the cold weather, but this and many other matters relating to this weed need further investigation.

The adjustable *bakhar* drawn by four bullocks walking abreast is all that is required for the occasional deep cultivation of black cotton and other Indian soils. More expensive machinery does not appear to be necessary, and in future any well-to-do cultivator can obtain for the trifling sum of forty rupees all the benefits of a tractor or steam plough without any of the disadvantages of these costly and uncertain machines. The deep cultivation involved in the eradication of *kans* produces other useful results. The land becomes remarkably free from weeds and the cotton crop is considerably benefited. The complete ridging plough is also proving useful at Indore in growing cotton on flat beds separated by furrows. The additional surface drainage so provided is followed by better root-development and by increased growth.

This method of eradicating *kans* and other deep-rooted grasses was demonstrated at the recent Agricultural Exhibition held at Poona in October 1926. It attracted wide attention and a large number of orders for the new yokes and for the complete outfit were received. Yokes are supplied for Rs. 11 f. o. r. Indore, iron parts of the yokes are sold for Rs. 3, while the complete outfit, consisting of yoke, chain and the converted ridger, costs Rs. 62 f.o.r. Indore.





ADJUSTABLE BAKHAR FOR KANS ERADICATION WITH YOKE FOR FOUR OXEN.

A METHOD OF IMPROVING THE FEEDING VALUE OF STRAW-CHAFF.*

BY

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As is well known, a considerable portion of the food of oxen in India consists of the dry stalks and chaff of cereals (*bhusa*) such as wheat, barley, rice and various species of millet. On account of their greater powers of digestion, buffaloes consume these residues more freely than work cattle and appear to derive much more benefit from them. The question, therefore, arises——Is it possible to assist the stomach of the Indian ox in making more use of these various kinds of straw and chaff ? Preliminary experiments on this subject, carried out at the Institute of Plant Industry, Indore, suggest that the answer to this question is in the affirmative.

The method adopted at Indore in making wheat and millet straw more palatable for the work cattle is that worked out by the late Mr. Jonas and described in the *Journal of the Royal Agricultural Society of England* (Vol. VI, Second Series, 1870, p. 119). The wheat chaff was mixed with a small quantity of green stuff (tares or green rye cut into short pieces by a chaff-cutter) and salt in the following proportions : chaff 20 cwt., green stuff one cwt., common salt one bushel. After admixture, these materials were well trodden down in a barn. Fermentation ensued, the temperature of the mass rose somewhat, and the wheat chaff was finally transformed into a material with the smell of new mown hay. Sheep and cattle ate the fermented chaff with avidity.

In the succeeding volume of the *Journal of the Royal Agricultural Society of England* (Vol. VII, Second Series, 1871, p. 85) there is an interesting paper by the late Dr. Augustus Voelcker, F.R.S., on the food value of the fermented wheat chaff prepared by Mr. Jonas. Dr. Voelcker's analyses of this material and of ordinary unfermented chaff showed wide differences as will be seen from the following table :—

* Paper read before the Agricultural Section of the Indian Science Congress, Lahore, January 1927.

TABLE I.

Composition of fermented and un-fermented wheat-chaff.

	Fermented chaff	Unfermented chaff
Moisture	7·76	13·33
Oil and fatty matter	1·60	1·74
Albuminous compounds	4·19	2·93
Sugar, gum and other organic compounds soluble in water	10·16	4·26
Digestible fibre	35·74	19·40
Woody fibre (cellulose)	34·54	54·13
Insoluble mineral matter (chiefly silica)	3·20	3·08
Saline mineral matters	2·81	1·13
	100·00	100·00

These figures show that the fermented chaff is much richer than ordinary chaff in albuminoids, sugar and digestible fibre.

The experiments at Indore were commenced on May 13th, 1926, using ordinary wheat *bhusa* and millet stalks (cut up by means of an ordinary chaff-cutter). The green material employed was chaffed maize such as is now-a-days used for silage. The proportions adopted were :—Green maize 3 maunds, *bhusa* or chaffed millet stalks 27 maunds, common salt 30 seers. Two other similar mixtures were made omitting the salt. After thirty-five days, fermentation ceased when the various mixtures were fed to the work cattle. Compared with ordinary *bhusa* and millet stalks, the amount consumed was greatly increased and there seems no doubt that the results obtained by Mr. Jonas apply to Indian conditions and that the food value of one of the most important fodders of the work cattle in this country can be considerably improved at small cost.

No advantage appeared to be obtained by the use of common salt in the mixture and in future this will be omitted. The proportion of green maize was rather too high and still better results are likely to be obtained by reducing this by one half to about the same proportion as that employed by Mr. Jonas, namely, one cwt. to the ton of chaff. In the case of chaffed millet straw the mixture was rather too permeable to the atmosphere and better results could probably be obtained with a mixture of *bhusa* and millet straw in equal parts.

The research programme at Indore does not admit of this question being followed out in great detail. These preliminary results are, therefore, published in the hope that some agricultural chemist in India, on the look out for a profitable subject for investigation, will follow up this question and work out the best method of getting the most out of the straw and chaff of the chief cereal crops of India.

SELECTED ARTICLES

THE RELATION BETWEEN CULTIVATED AREA AND POPULATION.*

BY

SIR DANIEL HALL, K.C.B., F.R.S.

Recent considerations of the problem of the capacity of the world to continue to feed its growing population appear to have begun with the late Sir William Crookes's address as president of the British Association when he discussed the ultimate curtailment of the wheat supply through exhaustion of the soil nitrogen. Crookes's views attracted little more than academic attention at the time (1898) because the great tide of wheat that was setting in from the newer countries still in the process of exploitation was barely slackening; moreover, Crookes had neglected a factor then imperfectly appreciated—the fact that land under any of the conservative systems of farming adopted in the old settled countries does not become exhausted. Generally speaking, a soil will remain itself indefinitely at a certain level of production. Latterly in Europe that level has been raised by the introduction of extraneous fertilizers. In his review Crookes predicted the development of the synthetic processes of bringing nitrogen into combination which are to-day rendering that prime element of fertility so abundant and so cheap.

Though we no longer fear the exhaustion of soils, of late years certain sociological considerations have revived interest in the old thesis of Malthus. Over-population and unemployment have become terrible realities in Great Britain and other countries; many States are finding themselves under pressure to maintain their standard of living against the intrusion of neighbouring races propagating recklessly down to the barest margin of sustenance. Again, various studies of the course of prices of wheat have led to the conclusion that before the War the real price was rising continuously, and that this tendency is manifesting itself again, however much the true sequence of prices has latterly been obscured by fluctuations of currency.

* Presidential address to Section M (Agriculture) of the British Association, delivered at Oxford on August 9, 1926. Reprinted from *Nature*, No. 2965.

These considerations led Mr. Keynes to envisage the approach of scarcity; his attitude is very much a return to Malthus. On the other hand, Sir William Beveridge, addressing the Economics Section two years ago, dismisses this fear as regards the world at large; whatever may be the troubles in Britain, "the limits of agricultural expansion are indefinitely far." On the whole, that seems a very safe proposition; it has been so amply fulfilled for the last hundred and fifty years—during the greatest expansion of population the world has ever known—that it would almost seem to be necessarily true, especially as it can be buttressed by agricultural experiments showing the enormous potentialities of production from the soil.

There is, however, one aspect of the case that appears to have received insufficient attention: the capacity of agriculture to provide food for the people depends upon the extent of land available as well as upon the pitch of cultivation. To what degree can the tuning-up of methods be made to compensate for a non-expanding acreage? The first step towards a more exact consideration of the problem may therefore be an estimate of the amount of cultivated land that is required to maintain one unit of population—man, woman, and child.

We may make our estimates by either of two methods—abstract or actual. The Food (War) Committee of the Royal Society adopted the figure of 2,618 calories as representing the minimal daily energy requirement of one unit of the population, and calculated that the actual United Kingdom consumption in the five years 1909-1913 amounted to 3,091 calories per head per day. An average English acre of wheat yielding 32 bushels will produce food, in the shape of wheat, flour, and pig obtained from the offals, of a calorie value of about 2½ millions. As the average consumption was about 1·13 million calories per head per year, we arrive at the conclusion that one acre of wheat would support more than two head, the relationship being more exactly 0·45 acre to feed one unit of population. But this figure is of no service in our more general consideration. The yield of wheat of 32 bushels per acre is far above that of the wheat-producing areas, and is that of only a few selected countries growing but a limited acreage. It is again the produce of land under the plough, and is consumed in the main as a vegetable product.

The great areas of grassland have a lower output of energy than the cultivated land, and the conversion of vegetable into animal food, whether of natural or cultivated fodder crops, is always attended by a great waste of energy. In the most economic production of pig-meat or milk, the energy recovered is only about one-sixth of that consumed, and this represents the machine at the top of its efficiency. The longer period of beef production results in a recovery as beef of only one-eighteenth of the energy consumed, and in practice the actual wastage of fodder and feeding-stuffs doubles or trebles the inevitable losses by conversion. Moreover, just as man is not a vegetarian making the most of the mere sustaining power of the land, so he does not use the land for food alone, but also for drink, for wool and fibre and other industrial materials, and for amenities.

We shall not get far on the theoretical basis, and I have only mentioned it as indicating the order of the superior limit of the maintaining power of land.

THE UNIT OF MEASUREMENT.

We must approach the question in a more empirical fashion and endeavour to ascertain the existing relation between the land in use and the people fed by it. Taking again the estimates of the Royal Society's Committee, it concluded that the United Kingdom production of food for the five pre-war years was 42 per cent. of the food consumed ; 46·7 million acres of cultivated land then produced 42 per cent. of the food consumed by a mean population of 45·2 millions, which works out to 2·5 acres to each unit of the population. This figure, however, is somewhat misleading in that it does not do justice to British agriculture, since our farming is to a considerable degree concentrated on the more costly elements of diet like meat or milk rather than upon cereals and sugar. For example, 49 per cent. of the food production at home, as against only 24 per cent. of the imported food, consisted of animal products.

The importance of this relation between cultivated area and population is so great, and the calculations by which it can be ascertained are so approximate and subject to so many estimates of a speculative kind, that I may be allowed to set out various results obtained by different methods.

We may begin by comparing population and area of cultivated land for all European countries except Russia, to which we add the United States, Canada, Argentine, Australia, and New Zealand, as the white countries which are also the chief exporters of food to Europe. I exclude all oriental countries because in them the mass of the population possesses a different standard of living, and I have excluded the other South American States and the Union of South Africa and other African colonies because they all possess a very large 'native' population and their exports do not bulk large in the food account of Europe. We must recognize, however, that the errors in the calculation will be loaded on to one side, because all the unenumerated countries, Russia and the tropical lands, are to a greater or less degree exporters and not importers of food. However, with this proviso we find that in the States enumerated there are 464·1 million hectares of land under cultivation and a population of 481·5 million persons, or 2·4 acres per head.

In the United States about 356 million acres are in cultivation : from this may be deducted as producing exported materials, for cotton 24, for wheat 16, for maize 2, for meat products 22 million acres, or 65 million acres in all. Other products are exported but may be regarded as balanced by imports, so that we find 291 million acres of cultivated land devoted to supplying a population of approximately 112 millions, or 2·6 acres per unit of population.

France, we know, is a country that is largely self-supporting ; it has a population of 39·3 millions and 36·3 million hectares under cultivation. To this acreage

we must add 0·9 million for imported wheat, 0·5 for other cereals, and 1·1 for imported meat; the exports of wine and fruit we may regard as balanced off by other imports. The net result is approximately 1 hectare, or 2·4 acres, for each head of the population.

A similar calculation applied to Spain, a country in the economy of which neither exports nor imports of food play a large part, gives more than 4 cultivated acres per unit of population; but then the so-called "cultivated" land includes a considerable proportion of mountain pasture of a very low order of productivity. On the other hand, Denmark, with the most highly developed agriculture of all countries, shows a production well above the average. A much closer calculation of production is possible for Denmark than for other countries—the data are set out in Mr. Harold Faber's paper before the Royal Statistical Society in 1924. Denmark is a country exporting agricultural produce chiefly in its most costly form as meat, butter, and eggs, but the means for equating the export against consumption is supplied in Mr. Faber's paper by the reduction of production and imports to food units. Making the necessary corrections for imports, it would appear that for the years 1909-1913 the population of Denmark was maintained on 63 per cent. of the production of her own land, or 1·82 acres per person.

Putting the various estimates together, we arrive at the conclusion that under the existing conditions of agriculture among the Western peoples, it requires something between 2 and 2½ acres of cultivated land to supply the needs of one unit of population living on the standard of white peoples.

We may confirm this estimate by a consideration of the growth of population during the last century. Between 1800 and 1920 the number of the white peoples increased from about 200 millions to about 700 millions. Data, however, for the land under cultivation in 1800 are very imperfect, and again there was another factor of improved agriculture which came into play in the first half of the nineteenth century. If we take 1870 as our jumping-off point, we may estimate the increase in the white man's numbers up to 1920 as approximately 225 millions. During the same period the addition to the cultivated lands in Europe, United States, Canada, Argentina, Australasia, and South Africa, the countries which have provided the white races with food, has amounted to about 450 million acres. Again we reach a relation between cultivated land and population of between 2 and 2½ acres per head.

This brings me to the central point of my argument that an increase of population is in the first instance dependent upon an increase in the area of cultivated land. The expansion of the white peoples in the last century was an event unprecedented in the world's history, and was achieved only because of the vast areas of unoccupied land, chiefly in the Americas, which suddenly became available for settlement through the power conferred by the railroad, the steamship, and modern weapons. It will be noticed that the population of Europe previously had become comparatively stable, even as it has become approximately stabilized in France at present—the

expansion came with the opening up of the new lands and in proportion to the amount that could be settled.

ENERGY VALUE OF PRODUCE.

Accepting as a basis for further discussion that under the present system of agriculture something more than two acres of new land will have to be brought under cultivation for each unit of increase in the population, we may examine if any means exist of modifying this relationship before considering its consequences.

I have already suggested that a vegetarian diet is the more economical of the resources of the soil, and that meat and all animal products like milk and eggs are produced with an expenditure of energy which may be so low as seven but also so high as twenty times the energy available from them. It is true that to a certain extent the animal will utilize material otherwise of little service to man, like milling offals and low-grade fodder crops—roots, hay or straw. None the less, if the maximum of population supported by a given area of land is the objective, vegetarianism becomes increasingly necessary, as we see among the crowded populations of India and China. At the same time, the tillage of lands, now given up to the grazing of animals becomes possible because of cheapness of labour resulting from a redundant population. Most of the beef and mutton supply comes from land left untilled because of the costliness of labour relative to products ; the meat may represent a very low level of production from the land and yet a high cash return for the labour expended. Hence the apparent paradox of grazing being general in Middlesex because of the proximity of London.

Another item of waste which would have to be eliminated in case of stern necessity is the conversion of potential food into alcoholic drink. Great Britain ferments the equivalent of one and a half million acres of barley. France devotes 4,000,000 acres, nearly 4·5 per cent. of her cultivated area, to vineyards. Without going so far as to say that beer or wine possesses no food value, it is certainly not half of that which could have been grown from the land thus used for the production of drink. In such matters it is vain to prophesy, but I cannot help feeling that the race (not individuals) which cuts out meat and alcohol in order to multiply is of the permanent slave type destined to function like worker bees in the ultimate community.

INTENSIFICATION OF PRODUCTION.

The second question that merits very careful consideration is whether the current agriculture cannot be intensified so as to bring about a great increase of production from the existing area of cultivated land. A cursory examination of the average yields of our chief crops in different countries shows what an immense potential

increase of production is here open. The average yield of wheat (1921 to 1924) for all the countries of the world collecting statistics was 13·2 bushels per acre; the average yield in Denmark for the same period was 41·4 bushels per acre—more than three times as much. Of course, the area devoted to wheat in Denmark is about 200,000 acres in all, or 3 per cent. of her arable land, whereas the wheat acreage of the world amounts to about 250 million acres. The mass production of wheat in the world is from countries of low yield; more than half is grown in countries in which the average yield is less than 13 bushels per acre.

It is from these countries with the low yield per acre that wheat is exported, and their production determines the world market, with the consequence that wheat production has been increasing in these and similar countries, while it has been shrinking in the European countries with a higher yield per acre.

The dominating factor has been cost of labour; speaking broadly, it may be said that increased yields per acre are associated with higher expenditure per bushel for labour and the great wheat-producing countries with a low yield per acre are the countries with a correspondingly high yield per man employed. It may be estimated that in England a man's labour produces about 960 bushels of wheat, in Australia 1,500 bushels. A more exact comparison shows that in England the labour cost amounts to 1*s*. per bushel of wheat, against 8*d*. in Canada; this with an average wage rate of 30*s*. to 36*s*. a week in England as compared with 60*s*. in Canada.

All this goes to show that intensification is only to be purchased at the cost of labour, and that in the past, extending the cultivated area has been a cheaper way of getting the wheat required by the world than higher farming.

This general statement, however, does not tell the whole story; particularly it disguises the intensification of yield that may be obtained without a commensurate increase of labour. For example, the introduction of more heavily cropping varieties, originated by the skil of the plant breeder, may add greatly to the production from a given area without increasing costs other than those of harvesting and marketing.

One must not, however, expect too much of the plant breeder. Over the greater part of the cultivated land of the world the gross amount of production is limited by external factors such as water supply, temperature, available fertility of the soil, etc. For example, the wheats and barleys grown in England had long been subjected to selection and improvement before the scientific methods of plant breeding were evolved, and the further steps in improvement are going to be neither big nor easily won, depending as they do upon altering what Dr. Beaven has called the migration ratio, whereby the plant will convert more of the material obtained from the air into useful grain and leave less as straw. The chief opportunities, in fact, lie in the elimination of susceptibility to disease or destruction by frost, or general tenderness of constitution, by which means the range of the high-yielding cereals, or even of cereal growth at all, may be enormously extended.

Artificial fertilizers.

The general enhancement of production by processes which induce improvements of the water supply or the temperature, as by irrigation and drainage, soil amelioration, cultivations, etc., suffers from the disadvantage of calling for labour, until it may prove far more costly than the increased produce can repay. Fertilizers appear to offer more promise. It may be recalled that the general level of production from English land was raised by nearly 50 per cent. between 1840 and 1870. At the beginning of the period the average yield of wheat was of the order of 20 bushels per acre, this being the crop the land was capable of maintaining under a conservative rotation with no extraneous source of fertility. But between 1840 and 1870 artificial fertilizers were introduced and became a generally accepted part of British farming, with the result that the yield of wheat had risen to about 30 bushels per acre, though no other marked change in the routine of cultivation had been adopted during the period. The employment of fertilizers still lags far behind the opportunities of employing them to profit.

The various processes of bringing atmospheric nitrogen into combination to which the War gave such a stimulus, are now being developed on a vast scale in all civilized countries, and will result in an almost unlimited increase in the amount of nitrogenous fertilizer available at low prices compared with the prices of agricultural produce. Here at least is the opportunity for another step up in production from our cultivated lands comparable with the progress that was made between 1840 and 1870. It is not all plain sailing; the farmer has to study carefully where an increased supply of the cheapened nitrogen can be most suitably applied to his land and what changes in his system of cropping are demanded. The plant-breeders' art is needed; on most of our land any great enhancement of growth of cereals brought about by the use of nitrogenous fertilizers is attended with the danger of lodging. Few of our cereals possess stiff enough straw to remain standing on a soil enriched to the degree even that is reasonably practicable to-day. Thus the more immediate outlet for the new fertilizers would appear to be the fodder crops which are convertible into meat and milk.

In the solution of the main problem under discussion—the possibility of intensification of production from the existing farmed land to meet the needs of a growing population—the development of the synthetic nitrogen fertilizers must play a dominant part. Crookes's prophecy is coming true.

The economics of present-day agriculture.

The present annual increment in the white population may be estimated at about five millions. This taken alone, would necessitate the taking into cultivation of twelve million acres of new land every year. No process of the kind is going on; indeed, for many crops there has been an actual shrinkage in the acreage since the War. The shrinkage is doubtless no more than a temporary matter, the back-

water of the wild fluctuations of prices and values brought about by the War, but it does not promise well for that continued expansion of the cultivated area which the still growing population demands. Indeed, we may detect a new influence at work, the growing disinclination of the civilized peoples to continue in agriculture because of its small and uncertain returns as compared with those of other occupations.

The flight from the land is manifest equally among the wage-earners of large-scale agriculture and among the peasants or family farmers in whose hands resides the greater part of the cultivation, whether in the old settled countries of Europe or the newer exploitations of America. Again and again it must be urged that the determining cause is economic; for the last half-century, save for the abnormal War years, farming has not paid a return on the capital and labour expended comparable with that obtainable elsewhere. It has been said that even the American farmers of the Middle West, who cut prices for all the world, made no profits during the last half-century except those derived from the accret on of land values; and the peasant farmer, who counts neither the capital he has in the business nor the hours of labour he gives to his land who in Europe is held to the land by secular tradition, finds agriculture unattractive so soon as the growth of industries and the spread of communications render an escape possible. If not the peasan himself, at least the sons look for an easier and less exacting mode of life.

At this stage it would be impossible to begin to diagnose the causes of the comparative unprofitableness of agricul ure. Fundamentally it is due to the weakness of the farmer as a commercial unit; the smaller the farmer the more ruthlessly does he compete with his neighbours and reduce prices to a bare level of sustenance for his long hours of labour. Even the large farmers who can put into practice some of the economics of an ordered industry are helpless against the large commercial organizations which pass on their produce to the customers. Always there is the peasant farmer to cut prices.

I cannot, however, pursue this issue. I return to my original text: that if we are to continue to feed the growing population of the world on the present methods a continued expansion of the cultivated area is required; new land is called for year after year. I cannot see where this new land of the necessary quality is to be found in quantities commensurate with the immediate demand. Doubtless, the white races will insist on maintaining their rising standard of living and will apply deliberate checks to their fertility, a process we already see in action. But the restriction of increase will not take effect all at once even under economic pressure, and the danger lies in the period preceding the comparative stabilization.

As it cannot be supposed that the development of the civilized races can be allowed permanently to be checked by lack of food when food is obtainable, it follows that resort must be had to the intensification of production from the area already under cultivation. The means for that intensification are already in sight, more will be supplied with the advancement of research. Intensification, however,

is in the main attended by a higher cost of production, and movement in that direction is likely to be slow until it is stimulated by a rise of prices. Organization will have to be introduced into the industry, and it may be expected that organization will take one or other of three forms. The farmer may be left as the producing unit, but his methods will be strictly controlled and standardized by the great selling corporations that handle his produce, and these corporations may be either commercial ventures or co-operative associations of the farmers themselves. The co-operative venture appears to imply an even more rigid discipline of the individual than that imposed by the capitalist firm. Alternatively, the capitalist may venture upon the direct exploitation of large areas of land and industrialize farming as he has industrialized other producing businesses. But capital will only be tempted back to farming, whether for the organization of the business or even to enable the individual to take advantage of the possibilities of intensification, if prices rise to a definitely remunerative level.

I hope I have given reasons for supposing that prices must rise, because the surge in population set up by the unprecedented extension of the cultivated area last century cannot all at once be checked, whereas the new land still available is either inadequate in amount or unsuited to cheap production by the old methods. How close at hand the period of pressure may be it is unsafe to prophesy, but it may be agreed that pressure is sooner or later inevitable and that one of the biggest problems before the world at present is to prevent pressure developing suddenly or becoming unbearable. The intensification of production is the only remedy, and, again, the only means of rendering intensification practicable is the continued pursuit of scientific research.

SELECTING SIRES FOR THE DAIRY HERD.*

There is no more difficult problem in farm livestock breeding than the dairy sire, and when one of the principal aims is dual-purpose character the difficulty is increased rather than diminished. The choice of the sire is, of course, a matter of cardinal importance and of very great difficulty in all stock-breeding enterprises. There are many characteristics to be looked for in all sires according to the requirements of the breed, but in most instances all the qualities that meet the eye are as easily discernible in one sex as in the other. In the case of dairy cattle, however, milking character difficult to detect with certainty in the female is much more obscure in the male.

Beef is as easily discerned in the bull as in the cow, mutton and wool in the ram as in the ewe, bone action and symmetry in the stallion as in the mare, fleshing and form in boar as in the sow, and it is an axiom of stock-breeding that like tends to produce like. In building up the accumulation of merits that makes for prepotency and consistency we can examine, as far as our knowledge goes, the merits of all ancestors, but in the case of dairy cattle we have gaps all along the male side, including the bull, whose value we are trying to assess. For pedigree knowledge of the bull's worth for milk we must rely almost entirely upon the merits of the cows from which he is descended.

MILK RECORDS.

Milk records have, of course, helped to simplify the task of choosing a bull for a dairy herd, but it has also introduced dangers that are very real. It is common knowledge, indeed general experience, that a heavy milking cow does not always produce heavy milking daughters. We may have a fifteen-hundred gallon cow, some of whose daughters become her equal or even superior in milk production, while others, perhaps full sisters, cannot be prevailed upon to give half of this amount. We may even have cows, all of whose daughters fall short of them as milkers without any adequate explanation being discoverable in the breeding on the sire's side.

As daughters of a heavy milker may fail to inherit their dam's milking character, or may inherit it in varying degrees, so we may assume that her sons will vary. Indeed no guessing is required, for it is everyday experience that they do. In the female the lapse is detected, but we have to wait for another generation to discover it in the male. Milk records are a great assistance, but they do not provide data from which infallible deductions can be drawn.

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* Reprinted from *Farmer and Stock-breeder and Agri. Gazette*, No. 1894.

Blind reliance on records.

It has been mentioned that a real danger attaches to milk records, and this is to be found partly in a blind faith that a bull well bred for milk must produce heavy milkers, but chiefly in making the scales the supreme test, or worshippin at the shrine of exceptional records. In the breeding of pedigree cattle breed character must remain one of the primary considerations, and in the breeding of all dairy cattle form, stamina, and constitution cannot be ignored. It happens with all breeds that some of the heaviest milkers are in themselves moderate animals, judged by every standard except milk production, and it may be claimed that in the dairy herd milk production is almost the only thing that matters. Prolonged and persistent milk production is, however, largely a matter of stamina, stamina again of conformation, and conformation of consistent breeding to one standard. A blind trust in milk records must lead quickly into degeneracy, and prove a handicap rather than assistance. Because it is the object to breed heavy yielders it does not follow that the best results will always be obtained from breeding from those with the greatest yields to their credit.

The breeder's problem.

The breeder's problem is how best to combine breed character, conformation, stamina, and yielding power. What particular characteristic should he build upon ? Should he start with heavy yielding capacity, and try to graft the others on to it, or should he begin with the character and conformation, and work towards the yield ? I do not think that there can be any question about the latter being the safer course. Character and conformation are much more difficult to regain if they are lost, and when they are lost it is only a matter of time, and generally a short time before milking capacity goes with them. We do not require to go to poor milkers to obtain the necessary character and constitution, and heavy production does not necessarily mean that they must be absent. If we can get all the required qualifications in one animal it is likely to prove the one we are looking for, and if it transmits all its merits it certainly is. This combination, however, is so rare that it is negligible, and it is the safer plan to look first for primary merits, and take as much as we can of the others.

Success in dairy cattle breeding is founded upon constitution. Heavy milk production is a severe tax on a cow's system. No cow with a weak constitution can continue giving very heavy yields, heavy according to her size, but in the absence of cast-iron stamina she may ruin such constitution as she has. It is quite possible and very common for a cow to have milking character beyond her constitution, with the result that she and her race fade away. The use of a bull from such a dam can only end in disaster.

In the early days of milk recording one frequently heard the objection that it would destroy the capacity for good judgment, which would decay owing to disuse,

but so far from this being the case milk records increase the field for the exercise of sound judgment. They supply more precise information along one particular line, so that the breeder instead of guessing at certain things has trustworthy data to go upon. He does not find matters settled for him, but only obtains facts to help him to arrive at a decision.

Analogy with laying poultry.

There is a fairly close analogy between laying poultry and the dairy herd. In each case the return comes through an essentially female function. In both cases a sire's value can be gauged only by the performance of his daughters, but in poultry breeding the returns come much more quickly, so that breeding experience accumulates more rapidly. It has been found in poultry breeding that the big layers are seldom bred from stock with extreme egg records. The tax upon the constitution of the heavy layer is similar to that upon the constitution of the heavy milker.

Now all this might be taken to point to heavy yields in dairy cattle as a mistake. Far from it, for heavy yields must be the aim, and the only ultimate aim, in the breeding of dairy stock where dual-purpose character is not a plank of the breeders' platform. What I desire to emphasize is that the desired yields cannot be attained and retained without due regard to the constitution and stamina of which vigour is but a sign.

Importance of the udder.

There is another fault often seen in heavy milkers—a badly shaped udder. Indeed, many of our heaviest yielders have rather atrocious vessels. What, then, is the sense of striving after symmetry and shape of bag when the shapely vessel is outstripped in milk production by the ugly, pendulous, badly-balanced, split-up and windy-teated vessel ? Here again, however, we have to look to the future rather than the present. A good level vessel is much more likely to wear well, and is less liable to the ills that udders are heir to. The sloppy, pendulous bag is more liable to injury, and the coarse teats cost much more to milk. Incidentally easy milking does not perhaps get all the attention it deserves in these days of high wages ; a hard milker that keeps a man a few minutes longer at every milking brings a considerable bill against herself in the course of a year. The shape of the udder is not a fancy point set up against utility qualities. The stock-breeder has to wage a constant war against degeneracy and to the correction of faults—faults that in moderation are not a serious blot on the commercial value of an animal but that if allowed to develop unchecked would ruin any race of cattle. There can be no question that the sire is a very important factor in determining the shape of the udder, and a son of a cow with a bad udder is not likely to give satisfactory results even if the dam's record is exceptional,

Breed character.

The maintenance of breed type and character sometimes involve points that it is somewhat difficult to separate from the fancy, but one must always be careful before treating lightly any well-established breed characteristics. One of the faults we have to guard against in all breeds is degeneracy into mongrelism, with the loss of the prepotency built up by generations of careful breeding. Breed type is an important foundation in breeding for the future, and in maintaining a standard, and is an elementary factor that no breeder can afford to neglect. Indeed, in pedigree breeding it must be the foundation upon which all is built.

In the selection of the stock bull the breeder of dairy cattle has to study breed type, character, form, constitution, and pedigree. He must get not only a good bull, but one bred from good stock, as far as he can discover. He must get the best milk records in the immediate dams he can obtain, combined with these other qualities, and even so bulls will be found that fall much short of expectations. This failure of pedigree may sometimes be apparent in the beef male when it is hidden in the dairy-bred bull. The supreme difficulty is that the breeder has to discover it in the failure of his stock. He may have suspicions when heifers have reached in a year or so of age, but he has to wait until they have calved before he feels even fairly certain, and until the sire's daughters have reached second-calf stage, before he can be dogmatic. In other words, no one can speak with certainty about the dairy sire until he has reached five or six years of age.

ALLAHABAD AGRICULTURAL INSTITUTE. *

OBJECT-LESSONS IN SCIENTIFIC FARMING.

For decades it has been a truism that agriculture is the basic industry of India, and that its improvement through the application of science is a fundamental step in the material advance of this country. Yet comparatively few persons have taken a direct and active interest in the problem, largely because of its staggering bulk and difficulty. It was hard to know where to begin. A number of institutions, however, have been struggling with this problem, have already accomplished large results, and now that the public is being stirred with the necessity of larger efforts, are in a position of greatly increased usefulness. Of these, the Allahabad Agricultural Institute is one.

The Agricultural Institute was started in 1912, with the object of attacking the rural problem all along the line, but in particular of raising leaders for the campaign which could not but last for many years. For this purpose a farm was necessary, and about three hundred acres were secured on the bank of the Jumna, opposite the city of Allahabad. In order that the improved methods might prove themselves under unfavourable conditions, a very poor tract of land was selected. It was badly cut up by ravines, the fertility was extremely low, and much of it was badly infested with grass. One section was so poor that the zemindar had a standing offer of free rental to anyone who would cultivate it, but his offer was not accepted.

PROMOTERS' UPHILL WORK.

To bring this land into profitable cultivation without the investment of large sums of capital has been slow work. But practically all of the farm now produces a respectable crop, and much of it gives yields far beyond those of neighbouring fields. Much of the land is so deficient in organic matter that without manure it will never produce a satisfactory crop, but even these fields have been greatly improved by good ploughing and cultivation. Dry weather ploughing has been found to be the best way to eradicate the grass pests.

A deep gully, carrying a raging torrent during the monsoon, and dry and barren the rest of the year is not ordinarily considered an asset to a farm. But there were several such on the land of the Institute, and they have contributed much towards solving the problem of land reclamation. There are thousands of acres of land in this country which are useless because of such gullies and ravines, which are steadily eating into the good land and further limiting the amount which can be cultivated.

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* **Reprinted from *The Pioneer* Trade, Industrial and Economic Supplement.**

The average farmer knows no way to stop this loss, so accepts it as his fate. The Institute authorities were not willing to accept this view, and soon built a few experimental dams. These have been found highly satisfactory, and have not only prevented further erosion but have restored to productivity large areas of ground. All that is necessary is a dam which will hold up the water so that it will drop part of the soil and organic matter which it has washed away higher up the stream, and then allow the water to escape. The construction of such a dam is very simple, and comparatively inexpensive. The soil deposited is extremely rich, and yields an excell nt winter crop. Some of the dams on the Institute farm have more than paid for themselves each year since they were constructed out of the increased crop made possible. Without irrigation such land produces wheat four to five feet tall year after year. The Institute is situated in a district where only a small proportion of the land is irrigated, and where there is little likelihood of any great increase. The bulk of the Institute crops have, therefore, been grown under dry-farming conditions, although a tube well has furnished water for fruit and vegetable gardens. Recently, however, a supply of sullage water has been secured from the city. This makes it possible to grow a number of crops, such as sugarcane and potatoes, previously impossible, and to teach and demonstrate irrigation methods.

With the building of canals in many districts cheap water has become available, and the tendency has been to use it too freely. This not only restricts the amount of land which can be irrigated from any one canal, but also actually decreases the yield. It is probable that much of the injury to the land in certain canal districts could have been avoided by a more judicious use of the water. On the other hand, more water seems to be required in India than in the Western countries where water requirements have been studied. The importance of experiments to determine the minimum amount of water required, and of teaching prope methods of irrigation, thus becomes obvious.

With an increasing number of municipalities installing modern sewage systems the particular problems of sullage utilization are also deserving of attention. The Institute is working out methods which should enable the cities to dispose of the sullage both safely and to great economic advantage.

Problem of milk supply.

In many ways the problem of milk supply is the phase of agriculture most vitally affecting the general public, and it is certainly one of the most difficult of solution. From its foundation, the Institute has been working on this problem. There has gradually been built up one of the best modern dairy plants in this country, with a mixed herd of cows and buffaloes. The cows are of the Scindi breed, which is the best of the Indian breeds available in any numbers, according to an article by Mr. William Smith, Imperial Dairy Expert, in a recent number of the "Agricultural Journal of India." They are being crossed with three pure-bred American

bulls, two Jerseys and a Brown Swiss. This is calculated to increase greatly the production of the herd in a few years.

The cattle receive the best of care, and are fed according to the amount of milk produced by each, the rations found by experiment to give the best results. At all times the milk is handled in the most sanitary manner, and much of it is sold in Allahabad as certified milk. Butter, cheese, and other dairy products are also manufactured and sold. For this much modern equipment has been installed, including churns, vats, presses, a pasteurizer, and a refrigerating plant and cold store. Milk is also bought from the village *gowalas* and is pasteurized in order to make it safe, and is either sold as such, or is made into butter and cheese. All this milk is tested for purity and for butter-fat, and payment is made on the basis of pure milk, thus discouraging the practice of watering the milk. The *gowalas* are thus being educated to produce good milk and to care for it properly, and at the same time receive more for their produce than they could otherwise get. In time it may be possible to develop genuine co-operative marketing for these producers in the villages.

Through its direct contact with the farmers of the district, and through the many visitors who come from all parts of India, the Institute is thus making its influence felt for the improvement of farming methods. But such contacts are of necessity of limited number, and are not often sufficiently sustained to make much of an impression. The Indian farmer, like his brothers in other countries, prefers those methods which he has tried and knows will give some results, though they may not be very good. The Institute has, therefore, pinned its faith from the beginning to the education of students as the method which will in the end bring about the great reformation in Indian agriculture. The grade of work has slowly risen, but there have always been students taking regular courses in agriculture and the sciences underlying it.

Educational courses for students.

These students have come from all parts of India, and indeed from as far extremes as Mesopotamia and the Fiji Islands. Many of them have now finished their courses, and are farming, teaching and demonstrating the new methods in their own districts. The national scope of the Institute continues, and those already admitted to the dairy class opening next January include students from the Punjab and from Travancore.

Two courses of intermediate college grade are now being taught by the Institute, one in general agriculture, and one in dairying. The former leads to the Intermediate Diploma in Agriculture, given by the Board of High School and Intermediate Education of the United Provinces. This course was established only last year, and is taught also by the Cawnpore Agricultural College. It is open to students who have passed the high school examination or its equivalent, and is

of two years' duration. The training given combines the theory underlying cultivation with practical experience on the Institute farm, in such a way that students may proceed to higher courses or may undertake farming operations at once. Those who desire further training in the United Provinces may be admitted to the third year class at Cawnpore. The course for the degree of Licentiate in Agriculture given by the College, calls for more advanced work in the sciences, and for instruction in certain phases of agriculture not included in the lower course. It is not at present possible to get a university degree in agriculture in the U. P., although such degrees are given in the Punjab, the Central Provinces, Bombay, and Madras.

Students in the intermediate course study such basic sciences as chemistry, botany, zoology, physics, and economics. Some knowledge of each of these is necessary for the intelligent mastery of the more technical subjects, such as farm crops, horticulture, animal husbandry, irrigation and drainage, and farm machinery. They are prepared to tackle the problems of the farm, not only with a store of knowledge, but with a scientific attitude and with some ability to apply their facts to the particular situation. They will not be leaders in scientific research, but they will be able to apply intelligently the discoveries made by others, and to help other farmers also to profit by modern methods.

The Indian Dairy Diploma was instituted two years ago by the Imperial Department of Agriculture, and is designed to give in India the thorough practical and theoretical training in dairying for which it had previously been necessary to go outside of this country. A number of men with this training are required as managers of the military dairies, and for positions in the Imperial and Provincial Services. There is also an increasing opening for such men in private commercial dairies and dairy farms. This course is very highly specialized, treating of general farming only to an extent such that the students will be able to raise their own fodder and other crops necessary to the success of a dairy farm. Much emphasis is laid on the breeding, feeding and care of cattle, the handling of milk and the production of butter, cheese, *ghi*, casein, and other dairy products. Although the course has a thorough scientific foundation, with classes in chemistry, bacteriology, and genetics, it is a strongly practical course, and each student learns to do the work of a dairy with his own hands, and to do it well.

Teaching the Villager.

The Institute comes into more direct contact with the village problems through some of its lower courses. A primary school, with a distinctly rural flavour, and designed to prepare children for life in the village, teaches gardening, weaving, basketry, sewing, and other handwork, as well as the ordinary primary subjects. In connection with this school, teachers are trained in modern methods of education as applied to rural districts.

The vernacular course in general agriculture, designed to make more intelligent and therefore more prosperous farmers of those village boys who are unable to secure much education, has been temporarily discontinued. There is, however, an apprentice class where such students are taught simple farm mechanics, so that they may return to their villages and become very useful members of the community.

NOTES

THE MIXING OF COTTON VARIETIES.

The necessity of maintaining improved varieties of cotton in pure culture is now widely recognized. The greatest care is taken at many experiment stations to avoid the evil results of vicinism and also to prevent the mixing of seed during the process of ginning. A careful search in the literature on cotton, available in the library of the Institute of Plant Industry at Indore, has, however, failed to discover any mention of two other possible sources of admixture, namely, contamination of the soil with cotton seed used for feeding the work-cattle[1] and with seed left in the ground from a previous crop. Observations made at Indore during 1926 have shown that loss of uniformity in cotton varieties may arise from either of these causes.

The contamination of the soil through seed from the previous crop on the black soils of the Malwa plateau arises not so much from careless picking as from the secondary flowering of cotton which takes place in March at the beginning of the hot weather sometime after picking is finished. Unless care is taken to remove the old cotton stalks immediately after the last picking, a number of fully developed cotton seeds find their way into the soil and germinate after the first rains in June and July.

The mixing of cultures brought about by the cotton seed fed to the work-cattle is much greater than that arising from secondary flowering. Some attention has been paid to this matter at Indore during the present year, the results of which are described in this note. It was observed after a fall of 0·55 inch of rain on June 24th, 1926, that numerous cotton seedlings appeared on the surface of the manure pits and also to a smaller extent on land which had not been under cotton during 1925 but which had recently been manured with farm-yard-manure. These seedlings, in all probability, arose from the cotton seed used in feeding the work-cattle. This was fed whole up to April 1926 after which it was crushed in a mill before it was given to the animals. Contamination of the fields by these stray cotton seeds might have arisen in two ways—(1) through seed falling on the floor of the cattle shed and so finding its way into the manure pits and (2) from seed which passed through the stomachs of the oxen.

To determine to what extent viable cotton seed can pass through the alimentary canal of a working bullock, six of the oxen doing ordinary work were fed with un-

[1] In 1915, feeding experiments with wheat and gram were carried out at Lyallpur (*Agri. Jour. India*, X, p. 358) in which as many as 20 per cent. of whole wheat grains germinated after passing through the work-cattle.

crushed cotton seed for ten days; 2 lb. being given to each animal daily. The experimental animals were kept separate from the remainder and the dung passed during each night was collected and washed every morning for twelve days. In all, 11,571 complete cotton seeds were found in the dung; a nightly average of about 160 seeds for each animal. These seeds were sown at once in earth. Germination was considerably delayed and only 115 seedlings (one per cent. of the seeds sown) were produced. The remainder failed to grow but proved an irresistible attraction to dung beetles which rapidly devoured them although they were planted in soil in the ordinary way. A control plot of 500 seeds from the sample of cotton seed used in the feeding experiments gave a germination capacity of 66·8 per cent. The passage of the cotton seed through the alimentary canal therefore greatly lowered the vitality of the seed.

These results indicate the need of crushing or boiling all cotton seed before it is fed to the work-cattle employed on experiment stations and seed farms in India concerned with the improvement of cotton and the growth of pure seed for distribution to cultivators. [ALBERT HOWARD and S. C. TALESARA.]

THE SUGAR CROP OF NORTHERN INDIA FOR SEASON 1925-26.

An Occasional Correspondent writes in "The International Sugar Journal," Vol. XXVIII, No. 332:—

During the season 1925-26 19 factories operated in Northern India. Although complete statistics are not available, no substantial error arises in giving the total cane milled as about 675,000 short tons, from which was produced 54,000 tons of sugar more or less, making the average yield very close to 8·0 per cent. The largest quantity milled in any one factory was 64,000 tons and the highest yield reported from any one factory was 9·48 per cent.

Although data are far from complete, it would appear likely that the sugar content in the cane was lower than usual. This observation is to be connected with a severe epidemic of top borer, *Scirpophaga* sp., which was prevalent over the whole of Bihar and the United Provinces. A second cause contributory to a lower sugar content is to be found in the earlier start, due to a crop considerably in excess of any yet produced in the areas whence the 19 mills that operated draw their supplies; and yet a third cause may be connected with a monsoon more overcast than usual, resulting in less than the average quantity of direct sunlight.

During the past season very considerable areas of the Coimbatore seedlings have been reaped, amounting to some 4,000 acres more or less. Of this acreage about 50 per cent. is Co. 213, 30 per cent. Co. 210, and 20 per cent. Co. 214. For the coming season 1926-27, some 7,500 acres of these varieties have been planted: Co. 213 and Co. 210 representing the major portion of this acreage with a decrease in the proportion of Co. 214.

The return from these canes for the season just finished and taken over a very great proportion of the actual area is in short tons per acre :—

	Darbhanga area	Champaran area
Co. 210	16	13
Co. 213	20	17
*Co. 214	13	7
Hemja	10	7

Included in the Hemja returns from the Champaran area are many acres severely attacked by top borer, from the effects of which a recovery was never made.

As regards the sugar content of these canes, there is distinct evidence that Co. 214 may be profitably milled considerably earlier in the season than any of the others, but based on a series of detailed observations, there is no definite evidence that 210 or 213 are much, if at all, superior in this respect to the Hemja cane.

Although the hopes of a much higher sugar content have not materialized, nevertheless the superior cropping value of these canes, and their suitability to the untoward conditions which prevail in Northern India have more than justified the labour that has been spent in breeding and in extending the cultivation of these canes, and a very real benefit has been conferred on the cane planting community in the Indo-Gangetic Plain.

MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA, 1925-26.

Twenty-three factories making sugar direct from cane worked in India during the season 1925-26. Ten of these are situated in the province of Bihar and Orissa, nine in the United Provinces (of which one factory has not yet supplied its statistics) and two each in Bombay and Madras Presidencies. We are much indebted to the proprietors and managing agents of these factories for furnishing the statistics worked up in this note.

The table below shows the total quantity of cane crushed and sugar made by the factories in (i) Bihar and Orissa, (ii) United Provinces and (iii) Bombay and Madras Presidencies. The production of sugar direct from cane by factories in India totalled 14,14,523 maunds or 51,867 tons during the season 1925-26, as compared with 9,21,950 maunds or 33,805 tons during the previous season.

Province	Cane crushed		Sugar made		Molasses obtained	
	1925-26	1924-25	1925-26	1924-25	1925-26	1924-25
	Md.	Md.	Md.	Md.	Md.	Md.
Bihar and Orissa	90,87,98	55,38,418	7,25,735	4,40,966	3,68,995	2,05,641
United Provinces	65,70,650	32,16,198	5,22,135	2,32,717	2,97,737	1,59,715
Bombay and Madras Presidencies.	18,54,633	30 48 535	1,66,653	2,48,267	72,693	1,32,674
TOTAL FOR INDIA	1,75,13,271	1,18,03,151	14,14,523	9 21,950	7,39,425	4,98,030

There was thus an increase of 4,92,573 maunds or 18,602 tons in the amount of sugar obtained during the campaign 1925-26 as against 1924-25. It will be noticed from the above table that in 1925-26 the quantity of cane available for crushing in Bihar and the United Provinces was considerably larger, while that in Bombay and Madras Presidencies was smaller than that in 1924-25. This was due to an increase of 2 per cent. in the area planted with cane and high yields of improved varieties of Coimbatore canes at present grown in Bihar. The area under sugarcane in the United Provinces was 8 per cent. more than last year and the weather being favourable to the crop the yield was higher than in the previous season. In the Madras Presidency though the area under sugarcane was 4 per cent. higher than in the previous year, yet the outturn showed a reduction on account of unfavourable weather conditions.

The average yield of sugar in India per 100 maunds of cane shows an improvement, having risen from 7·81 maunds in 1924-25 to 8·07 maunds in 1925-26. This improvement is especially noticeable in Madras and the United Provinces, while in Bihar it is hardly worth mentioning.

During the season 1925-26 India's production of molasses by modern factories making sugar direct from cane totalled 7,39,425 maunds as compared with 4,98,030 maunds in 1924-25 or an increase of 2,41,395 maunds over the previous season. This is due to the increased amount of cane crushed this year.

Statistics regarding the production of refined sugar by refineries in India during the season 1925-26 will be collected and published in due course. [KASANJI D. NAIK.]

MILK YIELD AFFECTED BY TIMES OF MILKING.

From investigations extending over a period of three months at Missouri University in connection with the milk yield of cows as affected by times of milking, it would appear that a cow milked three times daily will give 110 per cent. of the milk given when milked twice daily ; if milked four times a day the yield will be increased to 116 per cent. Thus, an animal giving 10 quarts of milk a day with two milkings will give 11 quarts with three milkings and 11·6 quarts if milked four times a day. Such increases in herds may be worth considering, if conditions and costs justify the additional labour. [*West India Com. Cir.*, XL, No. 699.]

RESEARCH ON FOOT-AND-MOUTH DISEASE.*

Since Loeffler and Frosch in 1897 reported the striking fact that the fluid from the vesicles which form the main outward lesion of foot-and-mouth disease in bovines,

* Reprinted from *Nature*, No. 2918.

could, after dilution with water, be passed through kieselguhr filters without suffering loss of potency, it has been customary to regard the virus of this, perhaps the most contagious of all animal diseases, as belonging to the group of ultra-visible or filter-passing viruses. This demonstration by Loeffler and Frosch was, indeed, the first indication that an animal disease might be associated with a virus, the minute size of which permitted it to pass with ease through filters which retained the ordinary microscopic bacterial forms.

On the Continent, especially in France, Germany, and Holland, where foot-and-mouth disease has long maintained a strong foothold, experimental research has been very intensely and continuously prosecuted, largely with a view towards the elaboration of specific methods of prevention and cure. Though much information with regard to the properties of the virus emerged from these investigations, it cannot be said that any decisive solution of the problem of prophylaxis was reached which would be applicable, at any rate, to a country such as Great Britain, which is liable only to occasional outbreaks readily controlled, as a rule, by wholesale slaughter of affected animals and contacts. Further, the accumulated research data have been to some extent of uncertain quality, probably because of the expense involved in carrying out experiments on bovines on a sufficiently grand scale. It came, therefore, as something of a surprise when Waldmann and Pape in 1920 showed that guinea-pigs could be infected with the virus of foot-and-mouth disease. Loeffler's earlier results in this connexion had been negative and the non-susceptibility of small animals had long been regarded as a *chose jugée*.

The new knowledge, as might have been expected, immediately opened up a new and readily exploitable field for further experimental investigations of the foot-and-mouth virus. In April 1924, Frosch and Dahmen, working in Berlin, announced that they had succeeded in cultivating the virus through many generations on an artificial medium and that by a photographic process they had been able to render the virus visible.

It was at this juncture that the Ministry of Agriculture in Great Britain, faced with the severe and continuing prevalence of foot-and-mouth disease in the country, took the enlightened step of appointing a research committee of ten medical and veterinary experts, with Sir William Leishman as Chairman, "to initiate, direct and conduct investigations into foot-and-mouth disease either in this country or elsewhere, with a view to discovering means whereby the invasions of the disease may be rendered less harmful to agriculture." The first progress report of this research committee has just appeared. It contains no dramatic discoveries, but there is abundant evidence of carefully conducted work leading to decisive conclusions in regard to many hitherto obscure points connected with the properties of the foot-and-mouth virus. So far, the research has been conducted in two establishments, at the Lister Institute, where several workers specially engaged by the committee are being directed by Dr. J. A. Arkwright, a member of the committee, and at the

Ministry's laboratories at New Haw, Weybridge, where the work is under the immediate supervision of Sir Stewart Stockman.

Both groups have been working on very similar lines, and both have been employing the guinea-pig as the test animal with great success. The method of choice for inoculating this animal with the foot-and-mouth virus is the intracutaneous, in the hairless pads of the hind feet. In twenty to twenty-four hours redness and swelling at the site of inoculation give place to extensive formation of vesicles locally, and this is followed by generalization of the virus throughout the body, as evidenced by the presence of minute vesicles in the fore feet and tongue and by the infectivity of the blood. The energies of the workers were devoted in the first instance to traversing the claims of Frosch and Dahmen, but with the exception of one or two results of dubious interpretation, no confirmation whatever of the claims of the German workers was obtained. In Germany also, Frosch and Dahmen's claims do not appear to have received any acceptation. It has been apparent, in fact, that the virus tends to die out rapidly in a matter of hours, when kept at 37°C. on a variety of artificial media. Low temperatures, on the other hand, have favoured its survival.

Always, therefore, with the view of ultimate successful culture, efforts have been concentrated on testing the most suitable conditions for survival of the virus at a temperature of 37°C., and it has been found, for example, that in phosphate solution of p H 7·6 the virus can remain active for four or five days at 37°C. The virus shows a surprisingly high resistance to chloroform and alcohol. In 60 per cent. alcohol, for example, it preserves its potency for eighteen hours at room temperature, while organisms like *B. coli* and *S. pyogenes aureus* are killed in one minute under the same conditions.

Many attempts have been made to infect with the virus other small animals such as rats and mice. Accurate knowledge on this point was desirable, in view of the obscurity that not infrequently surrounds the paths of dissemination of foot-and-mouth disease. White rats, wild rats, white mice, and house mice only very occasionally give evidence of susceptibility to experimental inoculation. On the other hand, the long-tailed field mouse (*Apodemus sylvaticus*), twelve of which were tested, could be infected with ease. No evidence has emerged, however, to show that, either under laboratory or field conditions, foot-and-mouth disease can spread among these small animals.

Recently the Cattle Testing Station at Pirbright has been adapted for experimental work with cattle, sheep, and pigs, every precaution being taken to prevent the entrance or escape of infection. At this station, only, will such experiments be permitted. While research on foot-and-mouth virus with the guinea-pig as test animal is proceeding at approved institutes, the new experimental station will prove a most valuable adjunct for the final testing of varied material on bovines.

SOME DISEASES OF COTTON AS SEEN IN THE PLANTATIONS.*

In order to facilitate research work being carried out in the University of Manchester, for the Empire Cotton Growing Corporation, a visit was paid to some of the cotton States of America in the summer of 1924. The diseases of cotton described were observed in the plantations of North and South Carolina. In that season, according to recently published estimates by the United States Department of Agriculture, fungal and bacterial diseases of cotton reduced the crop in the United States of America by 1,900,000 bales. The extent of these losses in what was a relatively favourable season for cotton-growing indicates the importance of these diseases.

In the United States some diseases are more important than others, but, at the present time, all of them may be important to Great Britain in view of the considerable extension of cotton-growing in progress in various parts of the British Empire. In some of these countries a new crop plant is being introduced; we have little knowledge how it will react to its new environment and we do not know what diseases will appear. It is certain, however, that some diseases will occur, and it is well known that a disease which is relatively harmless in one country may become destructive in another. This may be illustrated by some of the diseases seen in the United States. *Bacterium malvacearum* causes the angular leaf spot and a boll disease on Upland varieties of cotton (*Gossypium hirsutum*), the leaves and bolls usually being the only parts of the plant affected. The Sea Island and Egyptian varieties of cotton (*G. barbadense* and *G. Peruvianum*) are much more susceptible to the attacks of the organism, which also affects the leaf-stalks and branches, causing the "black arm" form of the disease. This "black arm" disease is already causing serious concern in the Sudan on Egyptian cotton, although in Egypt, presumably on account of the different climatic conditions, it is not troublesome. It is now known that infection may be carried on the seed, and seed-disinfection has proved successful in preventing the disease in the United States.

Again, in the United States of America several root-diseases of cotton occur. Of these the Texas root-rot (Ozonium) and the wilt disease caused by *Fusarium vasinfectum* are of most importance. In the latter case the disease was studied in South Carolina on badly infected soils. The fungus present in the soil passes into the conducting tissues of the plant and, excreting poisonous substances, leads to dwarfing, wilting and killing of the whole plant. In the Sudan a root-disease (the Tokar root-rot), undoubtedly different from the *Fusarium* wilts or Texas root-rot, but capable of stunting and killing the plant by progressive infection, is also causing troubles. Work at present in progress on this disease should ultimately determine its cause and probably provide for its control.

Diseases of the immature or opened bolls are commonly caused in the United States of America by *Glomerella gossypii* (anthracnose disease), *Fusarium*, *Diplodia*,

* Substance of a paper read before the Manchester Literary and Philosophical Society by Dr. Wilfrid Robinson. Reprinted from *Nature*, No. 2932.

and by *Bacterium malvacearum*. The cotton lint is destroyed, weakened or discoloured by such organisms. Similar boll diseases occur wherever cotton is grown, and recent studies by Mr. R. W. Marsh on discoloured cotton from Nyasaland have shown that the yellow discoloration is due to a species of *Nematospora*, a fungus. In the West Indies this fungus has been shown by Nowell to be inoculated into the bolls by cotton stainer bugs, which puncture the bolls as they feed. Stainer bugs were observed feeding on cotton bolls in South Carolina, but up to the present the *Nematospora* fungus is not known to cause disease of cotton in the United States of America.

Other diseases of cotton studied were those caused by species of *Alternaria* and *Ascochyta gossypii*. These have not hitherto been of serious consequence in the United States, but the latter is now spreading and both diseases may prove much more harmful in other countries.

Of the diseases to which reference has been made, several have as yet been imperfectly studied, and only by extended work on such diseases and on the organisms responsible for them will it be possible for the growers and plant pathologists in cotton countries to guard against outbreaks of disease and to devise satisfactory means of control when such outbreaks occur.

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

Stimulation of seed growth.

A discussion of the possibility of increasing harvest yields by seed treatment (first proposed by Popoff). Manganese salts further the oxidation processes, while potassium iodide and sodium fluoride act directly in stimulating the plasma. The stimulation of plant growth by mineral salts is now definitely established. The activity of the leaves is most favourably affected. Magnesium salts in the soil act not as stimulants but as nutrient salts. [*Bot. Cent.*, 1925, **148**, 12 ; from *Biol. Zentr.*, 1925, **45**, 53. O. Loew.]

A further contribution to the study of the stimulation of seed growth by the action of Uspulun, Tillantin, Germisan, etc. The percentage increase in yield of treated seeds over untreated seeds is given in the case of red beet, carrots, peas and beans, and ranges from 17 per cent. to 66 per cent. increase. [*Bot. Cent.*, 1925, **148**, 12 ; from *Gartenztg. d. Osterr. Gartenbaugesellsch.*, 1925, **57**, 25, 26, 40, 41, L. Linsbauer.]

Cytology of Plant Cells.

The author has successfully attempted to apply to botanical material some of the newer methods in use by zoological cytologists but so far unrecognized by botanists. He concludes from his investigations that chondriosomes and plastids are one and the same thing, the latter being a more highly specialized product of the former. [*Bot. Abstr.*, 1925, **14**, 1158 ; from *Arch. Russes Anat. Histol. et Embryol*, 1918, **2**, 95-127. D. Nassonov.]

Investigation of Stained Seed Cotton from Nyasaland.

An investigation of a sample of diseased seed cotton from Nyasaland is described. The sample showed considerable discoloration of the lint, mechanical shattering of the hairs and also internal injury to the seeds. The discoloration of the lint is due to the presence of a yellow substance in the lumen which appears to have arisen in the developing hair as a pathological modification of the protoplasmic contents of the hair cell. There is no evident stain in the wall of the hair. Spores of a species of *Nematospora* were found in numbers among the hairs and within the injured seeds where mycelium and sporangia of the fungus were also observed. Neither spores nor mycelia proved to be viable. This species is apparently identical with the fungus described by Nowell as " Species C " and said to be one of the causes of lint staining and injury to cotton seed in the West Indies. The injury to the Nyasaland material is provisionally ascribed to this fungus, and it is suggested that the so-called boll-rot of Nyasaland is of the same type as the internal boll disease of the West Indies. A fungus similar to Nowell's " Species C " has been isolated from diseased material from Tanganyika ; the fungi differed slightly, however, in habit of growth. A number of other fungi belonging to various genera, together with two species of bacteria, have been isolated from the Nyasaland material. A species of *Cephalosporium* isolated has proved by inoculation experiments to be capable of reproducing the shattering of the hairs as seen in the original material. The characteristic staining of the hairs was not produced when immature bolls were inoculated with these fungi. [*Jour. Text. Inst.*, 1925, **16**, T. 315-322. R. W. March.]

Theory of Manufacture of Viscose Silk.

The author discusses the physical and chemical phenomena established and surmised, attending the individual steps of the viscose process.

Preparation of the soda cellulose. Cellulose is treated with caustic soda, as in mercerization, and a soda-cellulose compound is obtained. Already, in this first step, the cellulose probably experiences chemical and physical changes which may be responsible for the sensitivity of artificial silk to water.

Ageing. The soda-cellulose is allowed to stand for sometime. If the cellulose crystallite is considered as a cube (a sufficiently close approximation). it is found

that, during ageing, the length of the edge of the cube (referred to the length of the edge of the crystallites in the regenerated cellulose) has decreased; after 20-40 hours it is less by about ⅓ and at the end of 68 hours it is only about ½ of the original length.

Sulphiding. The soda-cellulose is treated with carbon disulphide (an amount about ⅓ less than the theoretical quantity required to form the zanthate is used) and the product is dispersed in caustic soda. The chemical nature of the process is still unexplained, but it is probable that the dispersed viscose particles are as big or contain as much cellulose as the aged soda-cellulose particles before treatment with carbon disulphide.

Ripening. Various changes take place during ripening and it is not known to what extent they are related. They include: (1) Chemical changes; the mode of union of the sulphur changes with increasing ripening. (2) Solvation changes (*i.e.*, in the retention of solvent by the micellæ). (3) Adhesion or agglomeration of the micellæ so that the originally liquid sol becomes more jelly-like until it finally forms a jelly which on application of pressure becomes a solid cake. The greater the degree of ripening the more advanced are these processes.

Spinning. The ripened viscose is spun through fine jets into a precipitating bath in which the viscose is coagulated and cellulose regenerated.

Coagulation consists in a closing together of the molecules which, possibly by reason of their closeness, possibly owing to condensing forces, so far adhere to each other that they form a coherent thread. Generally, the micellæ are not oriented with respect to the axis of the thread but form an unorganized mass. The *action of the acid,* apart from the chemical processes of cellulose regeneration, effects a series of changes of which the most important are the fixation of the micellæ to crystallites. By analogy with the formation of soda-cellulose and the xanthate, one xanthate micelle should furnish one cellulose crystallite. The mode of adhesion of the crystallites is unknown; the substances accompanying cellulose may form a cementing material, amorphous cellulose may play a part, or the crystallites may intergrow. That the substances accompanying cellulose form to some extent the embedding material between the crystallites (and this would supply an explanation of the dependence of artificial silk on the preliminary treatment of the cellulose) may perhaps be deduced by considering them as responsible for the low wet strength of artificial silk. They take up a large amount of water and allow the thread to "flow" when it is loaded. The cross-sections of artificial silk show that de-swelling and shrinking in the formation of the thread are considerably influenced by the previous history of the thread. A peculiarly constructed surface layer is always formed in a thread and this has a greater strength and is less sensitive to water than the inner material.

Washing, winding, etc. In these processes, with which lustre and strength properties are closely related, de-swelling and drying are of great importance but the processes have been little studied. Surveying the process as a whole, it would appear that an attempt is made to obtain the optimum particle size for viscosity and coagulation by the process of ageing and that this particle size does not appreciably change

throughout the process. In ripening, a certain degree of solvation is reached which is essential for the subsequent de-swelling and shrinking processes. Simultaneously, cohesion of the micellæ occurs and the micellæ by conversion to cellulose crystallites remain stable. This explains why fresh viscose gives an elastic thread and ripe viscose an inelastic thread. In the spinning bath, rate of coagulation, " cementing " and shrinking control the properties of the thread. [*Papier-Fabr.*, 1925, **23**, Fest. und Auslandheft, 115-117. R. O. Herzog.]

Acclimatization of cotton.

Experiments have demonstrated the efficacy of rouging and selection in overcoming the degenerative tendencies resulting from change of environment. As judged by lint length, size of seed, and lint index the quality of the crop at the end of three years' work seemed superior to that of the first year. Breaking of variety type into diverse forms was noted in all imported stocks, even in such pure strains as College No. 1. [*Exp. Sta. Rec.*, 1925, **52**, 734 ; from *Univ. Nanking Agric. Forest Serv.*, 1923, **1**, No. 6, pp. 45. J. B. Griffing.]

Cultivation of cotton in South Carolina.

Although closely spaced cotton was little earlier than widely spaced, during a very wet season the earliest and best yields come from spacing as close as 9 or 12 in. A spacing yielding 15,000 to 20,000 plants to the acre is the best, when an average of from 5 to 6 mature bolls will yield a bale to the acre. Acid delinted seed again excelled. Seasonal conditions affect the rate of hardening of the bolls, and they also seem to influence the period from the flower bud to the mature boll. A very definite correlation exists between the length of day and the boll period. Abortion of early buds and squares, evidently connected in some way with the unusually rainy season, is also commented upon. Topping late in the season had little effect on yield but the topped cotton seemed to open earlier and better than untopped plants. Results of fertilization, variety and time of planting tests are also given. [*Exp. Sta. Rec.*, 1925, **52**, 531-532 ; from *South Carolina Sta. Rpt.*, 1924.]

Description of cotton gin.

The supply of seed cotton to a gin of the kind described in Specification 187279 is controlled automatically by a float resting on the surface of the cotton on the reciprocating table. The float is carried by a pivoted lever connected through a link to a shield which covers part of the ratchet wheel on the spindle of the spiked roller which delivers the seed cotton from the hopper . When the float is raised the shield is moved so that the pawl moves over it instead of in engagement with the ratchet wheel. The pawl is reciprocated by a crank driven by a belt from the ginning

roller shaft. A spiked roller controls the feed over the table and a wiper removes excess from the roller. The roller and wiper are driven by a chain from the shaft of the crank and are mounted on a pivoted bracket so that they can be turned back to enable the knives to be adjusted. [E. P.. 239114. G. H. KARMARKAR.]

INTERNATIONAL CONGRESS OF SOIL SCIENCE.

We have received the following for publication :—

In accordance with the decision of the Fourth International Conference of Soil Science that met in Rome, in May 1924, the First Congress of the International Association of Soil Science, then organized, will convene on 13th June 1927, in Washington, D. C. The Congress will be followed by a field excursion to visit the various important soil belts in the country. Opportunity will also be given to the delegates to acquaint themselves with various agricultural industries, some of the leading agricultural experiment stations, and in general with the agricultural resources of the United States.

The Association is made up of the following six International Commissions :—

I. *Commission on Soil Physics*—Chairman—Dr. V. Novak, Chef de l' Institut Pedologique, Kvetna 19, Brno, Czechoslovakia.

II. *Commission on Soil Chemistry*—Chairman—Prof. Dr. A. deSigmond, Technische Hochschule, Szent-Gallertter, 4, Budapest, Hungary.

III. *Commission on Soil Bacteriology*—Chairman—Prof. Dr. Julius Stocklasa, Professor an der Böhmischen, Technischen Hochschule und Direktor der Staatlichen Versuchsstation, Vinohrady, Prague, Czechoslovakia.

IV. *Commission on Soil Fertility*—Chairman—Prof. Dr. E. A. Mitscherlich, Pflanzenbau-Institute der Universitat Tragheimerkirchenstrasse 83, Königsberg, Germany.

V. *Commission on Nomenclature, Classification and Cartography*—Chairman—Prof. C. F. Marbut, Bureau of Soils, Department of Agriculture, Washington, D.C.

Sub-Commission on the preparation of the Cartography of Europe.—Prof. Dr. H. Stremme, Mineralogisch-Geologisch Institut der Technischen Hochschule, Neptunstrasse 14, Danzig, Germany.

VI. *Commission on the Application of Soil Science to Land Cultivation*—Chairman—Dr. J. Girsberger, Kultur-Ingenieur des Kantons Zurich Kaspar Escherhaus, Zurich, Switzerland.

The American representatives of these Commissions are :—

I. Dr. C. Davis, Bureau of Soils, Washington, D.C.

II. Dr. M. M. McCool, East Lansing, Michigan.

III. Dr. S. A. Waksman, New Brunswick, N.J.

IV. Prof. D. R. Hoagland, Berkeley, California.
V. Dr. C. F. Marbut, Bureau of Soils, Washington, D.C.
VI. Dr. S. H. McCrory, Bureau of Agricultural Engineering, Washington, D. C.

Each Commission is now working on the preparation of its own programme. Some of the sessions will be devoted to the Congress as a whole or to combined meetings of more than one Commission, while a number of sessions (5 to 8) will be devoted to the special sessions of each Commission.

The programme of each Commission will consist of papers presented by invitation by outstanding investigators in the respective fields, and of papers presented by various workers in the different branches of soil science, by members or non-members of the Association. Titles of the papers to be presented and brief abstracts in English, French and German should be sent either to the respective Chairman, or to the American representative of the Commission where the paper is to be presented, or to the President of the Association, who will have the paper forwarded to the Chairman of the corresponding Commission.

This Congress will bring together in the U. S. A., for the first time in its history, all those that are interested in the different problems of soil classification, soil analysis, fertilization and treatment as well as the relation of the soil to plant growth. Extensive exhibits of various soil types (monolithic columns, in respective horizons) from Europe and America, apparatus used in soil analyses, of the soil microflora and microfauna, etc., will be held during the Congress.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. J. W. BHORE, C.I.E., C.B.E., I.C.S., has been appointed a temporary Member of the Council of the Governor-General of India (Department of Education, Health and Lands), *vice* the Hon'ble Sir Muhammad Habibullah Sahib Bahadur, K.C.I.E., KT., placed on special duty.

MR. R. B. EWBANK, C.I.E., I.C.S., has been appointed to officiate as Secretary to the Government of India, Department of Education, Health and Lands, *vice* Mr. J. W. Bhore on other duty.

THE University of London has conferred the degree of D.Sc. on Mr. J. T. Edwards, Director, Imperial Institute of Veterinary Research, Muktesar, for a thesis entitled "The Chemotherapy of Surra (*Trypanosoma evansi* infections) of Horses and Cattle in India."

MR. H. COOPER, M.R.C.V.S., Pathologist, and Mr. J. R. Haddow, B.Sc., M.R.C.V.S., D.V.S.M., Third Veterinary Research Officer, Imperial Institute of Veterinary Research, Muktesar, have been confirmed in the Indian Veterinary Service.

WE regret to record the death of Rai Rajeswar Das Gupta Bahadur, Deputy Director of Agriculture, Bengal, which sad event took place at Calcutta on 21st November, 1926.

MR. C. P. MAYADAS, M.A., B.Sc., Principal, Agricultural College, Cawnpore, has been granted an extension of six months leave on medical certificate in continuation of the leave previously granted.

MR. P. K. DEY, M.Sc., Plant Pathologist to Government, United Provinces, was on leave for two months from 25th October, 1926, Mr. S. D. Joshi officiating.

MR. G. C. SHERRARD, B.A., Deputy Director of Agriculture, has been placed on special duty at Sabour under the Director of Agriculture, Bihar and Orissa.

On the expiry of his leave, Captain G. G. HOWARD, M.R.C.V.S., Deputy Director of the Civil Veterinary Department, Bihar and Orissa, has been posted to the Orissa Range with headquarters at Cuttack.

THE Punjab Government has created a temporary post of an Assistant Director of Agriculture, Punjab, with effect from 1st July, 1926, and appointed thereto Khan Bahadur Maulvi Fateh-ud-din.

DR. Dalip Singh, M.Sc., PH.D., has been appointed Second Agricultural Chemist to Government, Punjab, with effect from 2nd August, 1926.

THE Punjab Government has sanctioned the addition of a post of Fruit Specialist to the staff of the Agricultural Department at Lyallpur and the appointment thereto of Mr. Lal Singh, M.Sc., from 28th July, 1926.

MR. T. RENNIE, M.R.C.V.S., Veterinary Adviser to the Government of Burma, has been permitted to resign the Indian Veterinary Service from 23rd November, 1926.

THE Woodhouse Memorial Prize for 1926 is awarded to Mr. R. D. Bose, B.Sc., Assistant to the Imperial Economic Botanist, Pusa, for an essay on "Reversal of sex in hemp."

REVIEWS

Lime in Agriculture—By Frank Ewart Corrie, B.Sc., N.D.A., N.D.D. (London: Chapman & Hall, Ltd., 1926.) Price, 3*s*. 6*d*.

This little book is divided into two main sections. The first part deals with lime in plant nutrition. The functions of lime in the soil are discussed and simple tests for the lime requirement of soils are described. Instances of plant diseases due to lime shortage in the soil are given together with practical experiences in the amelioration of such soils by liming. Some examples of increased productivity of arable land brought about by liming are quoted. Very many more experiments could have been quoted, and the reviewer would like to lay greater emphasis on this aspect than the writer was able to in his admirably condensed account.

The second part of the book deals with lime in animal nutrition. The importance of lime, the requirements of lime and the effects of a deficiency of lime in the ration are considered.

An appendix containing valuable reference data is provided. The information regarding lime supplements suitable for growing stock and for cows in milk should be especially useful to the stockman.

The book has been opportunely issued at a time when the question of mineral requirements for live-stock is attracting so much attention. The data refer almost entirely to English conditions, but the book is generally instructive on an important subject and will be appreciated by many agriculturists in this country. One aspect of the subject has not been dealt with. The effects of lime in increasing soil fertility and in checking plant disease have been considered, but the effect of lime and of manuring generally upon the quality of the crop has not been touched upon. The fact is we possess very little information on this most important subject. We know that mere quantity of green food is not sufficient to produce maximum health and growth. Somerville's classical work at Cockle Park has proved that quality of herbage can be more effective than quantity. In India it will probably be found that the quality of the foodstuffs, both for human and for animal consumption, is the question requiring most urgent attention. This subject deserves vigorous investigation in this country. [F. J. W.].

Essentials of Systematic Pomology—By BROOKS D. DRAIN. (The Wiley Agricultural Series.) Pp. vi + 284 ; figs. 106. (New York : JOHN Wiley & Sons Inc. ; London : Chapman & Hall.) Price, 13*s*. 6*d*.

THIS book is a text-book of systematic pomology and is not intended as a hand-book of orchard culture. It is divided into 21 chapters, each chapter being devoted to the description of the types of a particular fruit, *e.g.*, apple, etc. The points in which the different varieties of a particular fruit differ from each other are described both with reference to the mature fruit and the behaviour of the tree in the orchard. The book is chiefly of interest to those engaged in the fruit trade and is well illustrated ; it may prove of assistance to orchardists in Kumaon and Kulu. [F. J. F. S.].

NEW BOOKS

On Agriculture and Allied Subjects

1. Cotton and its Production, by W. H. Johnson. Pp. **xxvii**+536 ; 16 plates. (London : Macmillan & Co.) Price, 30*s*. net.
2. Potato Varieties, by Redcliffe N. Salaman. Pp. **xxii**+378 ; 10 plates. (Cambridge : At the University Press.) Price, 25*s*. net.
3. The Barley Crop : A Record of some recent Investigations, by Herbert Hunter. Pp. **viii**+166. (London : Ernest Benn.) Price, 10*s*. 6*d*.
4. The Marketing of Farm Produce. Part I : Live Stock. Pp. **viii** 103. (London : Oxford University Press.) Price, 3*s*. 6*d*.
5. Life of Plants, by Sir Frederick Keeble. Pp. **xii**+256. (Oxford : Clarendon Press.) Price, 5*s*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Bulletin.

1. List of Publications on Indian Entomology, 1925. (Compiled by the Imperial Entomologist and the Officiating Imperial Entomologist, Pusa.) (Pusa Bulletin 165.) Price, As. 12 or 1*s*. 3*d*.

Report.

2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau), for the year 1925-26. Price, Rs. 2-4 or 4*s*.

Miscellaneous.

3. The Catalogue of Indian Insects. Pt. 11—Brenthidæ, by Richard Kleine. Price, Rs. 1-2 or 2*s*.

ERRATUM.

The *Agri. Journ. India*, Vol. XXI, Pt. VI, pp. 440—443.

values of r instead of

$$r = \pm 0{\cdot}37 = 0{\cdot}06$$

should be read as follows,

$$r = -0{\cdot}37 \pm 0{\cdot}06.$$

EDITORIAL

The problem of the co-ordination of agricultural research in India has bulked largely in the evidence already given before the Royal Commission on Agriculture. The necessity for such co-ordination has been generally admitted. Opinion as to the best means of achieving it has varied considerably. In view of these facts, much additional interest is attached to the publication of " Scientific Reports of the Agricultural Research Institute, Pusa ", which includes reports from kindred Sections of the Imperial Department of Agriculture, for the year 1925-1926. The function of the Imperial Department of Agriculture—and especially the Pusa Research Institute has recently been the subject of much discussion and not a little criticism. When such criticism is the outcome of an earnest desire to improve the organization of agricultural improvement in India and to co-ordinate all forces working in that direction, it is most welcome and may be productive of considerable benefit to the country. When, however, the critics are actuated by less exalted motives, their judgments tend to become parochial and narrow and are in direct opposition to the growth of the team spirit and the " happy family " feeling which should permeate all workers, both high and low, in the great cause of agricultural improvement in India.

One of the most effective replies to the baser forms of criticism is the publication of such a series of reports as are under review in this article. In addition to their scientific interest, which is considerable, these reports on the work of the Imperial Department of Agriculture are most valuable in demonstrating, to layman and expert alike, the well-considered and widespread campaign which is being carried on against India's agricultural problems. Moreover, each section of the Report indicates the paramount importance of co-operation between the Imperial and Provincial Departments in the common work of improving the agriculture of the country. Many most pressing agricultural problems are essentially ultra-provincial in their nature, and effective and economic research towards their solution must be carried on on an all-India basis. The Ministers in charge of Agriculture in the provinces and their Directors of Agriculture have a valuable asset at their disposal in the staff and equipment of the Imperial Department of Agriculture. Whatever the shortcomings of the present organization under the Imperial Department may be, these Reports clearly indicate that they do not include any lack of desire to co-operate with research workers in the provinces. In the interests of the Indian cultivator, a fuller response is called for from the provinces. To-day the prospects of a co-ordinated and co-operative attack being launched against the scientific problems of agriculture in India are brighter than they have ever been hitherto.

There is no place for narrowness or prejudice in such a struggle, the successful outcome of which means increased happiness and comfort for millions of our fellow-countrymen.

The Reports under review include a series of accounts of the work done during 1925-1926 under the various Sections of the Imperial Department of Agriculture. These accounts are prefaced by the Report of the Director, Agricultural Research Institute, Pusa. Only the briefest mention of the most important items of work can be made in this article. Much of the work in the Botanical Section was devoted to multiplication of seed of the now-famous Pusa wheats and to additional botanical research on this and other cereal crops. Pusa wheat No. 52 is now being distributed in Bihar and Orissa and has given good yields in the Central and United Provinces. Trials with imported tobacco varieties have proved successful and, with suitable curing methods, the possibility of producing cigarette tobacco in Bihar suitable for overseas markets is within reach. In the Chemical Section, valuable work of all-India importance on the movement of nitrates in the soil and subsoil has been carried out. In addition, cane-growers will find much interest and profit in an account of experimental work on improving the quality of *gur*. The Report of the Bacteriological Section records the retirement from service, on 29th April 1926, of Mr. C. M. Hutchinson, C.I.E., Imperial Agricultural Bacteriologist, a post ably filled by him during the past sixteen years. Much important investigation was made in this Section on the conditions of activity of nitrogen-fixing bacteria in the soil, a subject of extreme importance in tropical agriculture. Experiments on increasing the efficiency of green-manuring and on the utilization of waste organic materials for manure were conducted to successful conclusions. The bacterial flora of silage was studied. In the Mycological Section, practical problems were attacked by a study of the wilt disease of pigeon-pea (*Cajanus indicus*) and other leguminous crops and of the mosaic disease of sugarcane. It is gratifying to note that special work was undertaken in this Section on the cotton wilt fungus at the request of the Special Cotton Mycologist, Bombay. The most effective methods of controlling several serious insect pests of crops were worked out in the Entomological Section, and numerous enquiries on insects, both economic and destructive, were replied to during the year under report. It is noteworthy that information on bee-culture was often called for.

The work in the Agricultural Section consisted of the continuation of permanent experiments in collaboration with other Sections of the Institute. The cropping of the Pusa estate is carried on with the main objects of maintaining the fertility of the soil and of producing a regular supply of green fodder for the well-known Pusa dairy herds. Average daily milk yields of fourteen and twenty pounds were obtained from the pure Sahiwal herd of 78 cows and from the half-bred Ayrshire-Sahiwal herd of 40 cows respectively. In the latter herd, there are 16 cows which have given over 6,000 lb. of milk per lactation period of 300 days. The policy now being adopted is to cross the half-bred cows with pure Sahiwal bulls in order to

adapt the Ayrshire milking strain to the needs of the country. Under the direction of the Sugar Bureau, the testing of new cane seedlings from the Coimbatore Cane Breeding Station was continued. The sugar cable service conducted by the Bureau on a self-supporting basis retains the appreciation of the trade.

The Report of the Imperial Dairy Expert contains much of interest and encouragement for all interested in the Indian dairy industry. Special mention is made of the model city milk plant erected by the Co-operative Societies Milk Union in Calcutta. This real practical attempt to organize a city milk supply on a co-operative basis is worthy of wide attention all over India. The proposed organization of a Cattle Bureau will be welcomed by all cattle-breeding interests in the country and is a definite step forward towards the establishment of registered herds of pure Indian breeds of cattle. As usual, much of the time of the Imperial Dairy Expert was occupied in advisory and consultant work, and it is gratifying to note that his report records a considerable increase in activities of this nature. Very important and valuable experiments on the nutrition of growing animals were carried out by the Physiological Chemist at Bangalore. Special interest is attached to a study of the nutritive value of Indian coarse fodders, and Mr. Warth seems to be in course of obtaining results of fundamental importance to the problems of animal nutrition in India. Work of much economic importance was conducted at Coimbatore under the Government Sugarcane Expert during the year under report. The increased profit to cane-growers from the cultivation of Coimbatore varieties in place of local canes is most striking in the Bihar cane-growing tracts.

In addition to the special activities of the different Sections of the Imperial Department of Agriculture, mention must be made of the valuable facilities provided for training Indian students in different branches of agricultural science at Pusa and Bangalore. During the year, these facilities were taken full advantage of and there appears to be no doubt that an early extension of this side of the work of the Imperial Department is urgently required.

With the exception of a personal visit to Pusa or Bangalore, there is no better means for an inquirer to realize the nature of the work which is being done by the Imperial Department of Agriculture than by a careful perusal of these Reports. One cannot fail to appreciate that much of the research work described is quite beyond the limited scope of research workers in a province, and that the majority of the results obtained—and in course of being obtained—are—and will be—of essentially all-India importance. The new appointments of a Physical Chemist and an Agronomist, which have been made during the year under report, indicate that the complexity of the problems to be solved is fully realized, and that nothing is being left undone by the Government of India to aid and assist science in the constant struggle to improve the conditions of life of the agricultural population of the Indian Empire.

W. J. JENKINS.

ORIGINAL ARTICLES

CO-OPERATIVE CONSOLIDATION OF HOLDINGS IN THE PUNJAB.

BY

C. F. STRICKLAND, I.C.S.,

Registrar, Co-operative Societies, Punjab.

THE issue of "The Agricultural Journal of India" for January 1922 contained a short article by Mr. Calvert, Registrar of Co-operative Societies in the Punjab, explaining the method by which the difficult problem of fragmentation had been approached with a certain measure of success. Our experience was then limited to the work of one year, ending on 31st July, 1921, and it will be useful now to review the situation after five more years of effort. Mr. Calvert explained that the procedure was to call together all persons directly interested in land in a given village, persuade them to accept bylaws whereby the majority in a general meeting might approve a method of repartition, and then carry out the actual adjustment of fields and holdings in such a manner that no single individual was left discontented. The new land taken in exchange for his old holding by each member of the co-operative consolidation society was to be retained for only four years, after which, if the members were discontented with what had been done, the proceedings would be cancelled, and each man would revert to his former holding. Details were given of 45 societies with 1,653 members, which had so consolidated an area of 8,000 acres as to reduce an approximate number of 11,000 fields to 2,000 fields. The average area per field was raised from three-quarters of an acre to nearly four acres.

Consolidation was then in progress in the three districts only of Gurdaspur, Hoshiarpur and Jullundur. Table I will show that we have now extended our operations over 12 districts, and the number of societies has risen to 255, as on 31st July, 1926. The special staff appointed by Government for this duty is confined to the nine districts of Jullundur, Gurdaspur, Hoshiarpur, Sialkot, Gujranwala, Gurgaon, Ludhiana, Ferozpur and Kangra; a few societies in Multan and Shahpur have been formed, and the repartition carried out, by the ordinary staff of Sub-inspectors paid by the Punjab Co-operative Union. The special Government staff worked for a time in the Gujrat District, but has now been withdrawn

TABLE I.

Number of societies.

	July 1921	1922	1923	1924	1925	1926
1. Jullundur . . .	13	33	49	64	80	99
2. Gurdaspur . . .	22	35	44	48	55	64
3. Hoshiarpur . . .	12	20	22	25	31	43
4. Ludhiana . . .	1	1	1	1	1	2
5. Sialkot . . .	1	1	2	3	10	22
6. Gujrat	..	2	3	7	10	10
7. Multan . . .	..	1	1	1	1	1
8. Shahpur . . .	..	..	1	1	1	2
9. Gujranwala . . .	..	..	..	3	3	6
10. Gurgaon . . .	..	..	..	..	..	4
11. Ferozpur . . .	..	..	..	..	..	1
12. Kangra . . .	..	..	..	..	..	1
TOTAL .	49	93	123	153	192	255

in the interests of concentration. As further expansion becomes possible, we expect to enter the districts of Amritsar, Ambala, Karnal and Rohtak, thus covering almost the entire area of the Eastern Punjab, while postponing the claims of the West. It is impossible and uneconomic to scatter a limited staff over the whole province, since imperfect supervision will result in a diminution of the outturn of work per man. The evil of fragmentation is also somewhat more intense in the eastern and central districts than in the West Punjab. Table II shows the membership, the area consolidated, the number of blocks before and after repartition, and the average area per *block* in each case. It should be noted that the record of fields has been replaced by that of blocks. If several fields belonging to a single owner are contiguous, they are counted as a single block, the separate numbering of the fields being a matter of revenue convenience with which the co-operative staff are not concerned. The reduction in the number of blocks therefore represents the precise enhancement of convenience to the cultivator in the course of his cultivation. No attempt is made to induce relatives to combine their separate holdings in a joint holding in order to secure an apparent reduction in their number. It will be noticed that the increase (from 0·7 to 3·6 acres) in the average area of a

TABLE II.

Progress in consolidation.

Year ending July	Societies	Members	Area (in acres)	Blocks and area before	Blocks and area after
1921	49	1,683	7,571	9,685 / 0·8	1,894 / 4
1922	93	3,609	14,554	22,652 / 0·7	3,670 / 4
1923 . . .	123	5,624	19,930	31,858 / 0·65	5,241 / 3·8
1924	153	7,723	28,050	43.739 / 0·65	7.395 / 3·8
1925	192	10,349	39,757	63,056 / 0·65	11,135 / 3·6
1926	255	12,649	60,015	88,710 / 0·7	16,458 / 3·6

block is proportionately the same as the increase (from 0·8 to 4 acres) which was obtained in 1921. The decrease in the size of the blocks themselves is due to the consolidation of irrigated land ; the work of 1921 was to a large extent confined to unirrigated tracts. Irrigated fields and irrigated blocks are usually somewhat smaller than unirrigated, in areas in which wells are in common use.

The number of societies is slightly greater than the number of villages in which societies have been formed, since a suspicious community will sometimes hand over part of its land to the co-operative staff for consolidation as an experiment, and will only surrender their more valuable tracts to this perilous process when they have been satisfied with the result of their first venture, and the first society has been duly registered. A second society is then frequently required for the consolidation of another part of the village, if the owners of the second part include a number of persons who were not interested in the former society. For the most part, however, we are able to insist on the entire surrender of the village area, and to refuse to undertake a partial consolidation, in the districts in which the idea is now familiar to the people. The practice of registering a society, so soon as the members have accepted the bylaws, has been abandoned, and no society is registered until repartition has been carried out and the necessary changes in the revenue papers have been made and approved. The power of the majority under the bylaws to exercise compulsion on the minority, if discontented with either the plan or the result of repartition, has never been exercised, and we continue to cut our losses and leave the village if even a single owner of the smallest field remains obstinate. Since a refusal of this kind may occur at the very last moment when the entire repartition has been planned and completed, it may happen that six

months' labour is entirely wasted through the stubbornness or malice of an individual. No society is then registered and the time spent and work done do not appear in the tables.

Table III shows the number of the special staff of Inspectors and Sub-inspectors

TABLE III.

Staff and cost.

From April 1st	1921	1922	1923	1924	1925	1926
Inspectors	2	2	2	2	2(5)	5(7)
Sub-inspectors . . .	10	10	10	10	10(50)	50(70)
Area in acres on July 31st .	7,571	6,983	5,376	8,120	11,707	21,258
Cost to July 31st. . .	Rs. 5,866	14,562	16,292	17,651	29,865	70,534
Cost per acre . . .	Rs. 0-13-5	2-11-4	2-0-1	1-8-2	1-6-3	(3-5-1)

appointed and paid by Government from April 1st in each financial year. It shows also the area consolidated in acres during each year ending on July 31st, and the cost of the staff during the 12 months ending on that date. The figures of cost, therefore, include the pay and allowances of the staff for four months from April to July in the years 1925 and 1926, when the staff was increased with effect from April. A new Sub-inspector is not able to produce results or send up a society for registration within four months; the increased staff as on 1st April, 1925, and 1st April, 1926, has therefore been shown in brackets, and the staff actually working in the previous years should be regarded as having carried out the consolidation of the year ending on 31st July. For the same reason the apparent cost per acre, obtained by dividing the total cost of a given year by the total number of acres consolidated, is misleading. The area completed by July 31st in a given year has more nearly been carried out at the cost shown in the preceding year than at the cost shown in the column of the same year, and the cost per acre has been calculated accordingly. Broadly speaking, therefore, the cost per acre may be regarded as varying from Rs. 1-6 to Rs. 2-11, with a tendency to decrease. The final figure of Rs. 3-5-1 is irrelevant, since the work done by the additional two Inspectors and 20 Sub-inspectors from April to July 1926 will appear in the area consolidated up to 31st July, 1927.

The staff employed is drawn from the Revenue subordinates of the districts concerned. A village accountant (*patwari*), whose ordinary pay is from Rs. 20 to Rs. 26, is lent to the Co-operative Department for duty as Sub-inspector on Rs. 60.

Similarly a Revenue Qanungo, ordinarily paid Rs. 40 or Rs. 50, is employed as Inspector on Rs. 100, and draws travelling allowance at the usual Government rates. Since the Sub-inspectors are required to live for long periods in one village, and it is important to prevent them from imposing a burden on the villagers, they receive a fixed allowance of Rs. 30 per mensem. These rates may be regarded as high, but there can be no price too high for honesty. It is found that men on this pay will value their position, and despite our apprehensions there has been only one detected case of partiality. The offender in this case was not one of the special consolidation staff. Revenue subordinates, who are found to be unsuccessful or in any way untrustworthy, are returned to their former duties on their former scale of pay, and this prospect appears to be a sufficient deterrent. A critic will perhaps consider that the cost to Government of the consolidation in question is considerable, while the benefits accrue entirely to the owners and cultivators. The following instances will disprove this opinion. When the Ghazipur Consolidation Society was registered in 1921, the 245 acres of unirrigated land, to which the repartition applied, were paying a revenue of Rs. 1-9 per acre. The cost of consolidation (Inspector and Sub-inspector) was Rs. 157-8. Without bringing the fields of a single owner together in one place there was no hope that wells would be sunk, and this rate of revenue would presumably have been maintained at the next settlement, which is due in 1945. As a consequence of consolidation 15 new wells, irrigating 150 acres, have already been sunk and a still larger number are likely to be constructed. The rate of revenue on irrigated land in the adjoining village is Rs. 4-9-6, and without taking account of possible other wells, the revenue on 120 irrigated acres at this rate, if it be not increased at the next settlement, will be Rs. 551, as compared with Rs. 187-8 at present. Allowing interest at 6 per cent. for 24 years (1921 to 1945) on Rs. 157-8 as cost of consolidation, the total charge to Government rises to Rs. 384-8. The total cost of consolidation *plus* interest will therefore be recouped by Government in the first year after the new settlement, and will continue to be repaid in each successive year.

Take another instance. In the village of Balloki a Sub-inspector and an assistant were employed for 20 and 11 months, respectively, in the consolidation of 1912 acres at a cost of Rs. 2,390. Adding interest for 21 years, the total cost rises to Rs. 5,401. The owners have already sunk 13 new wells, which irrigate 130 acres. A further area of 84 acres, formerly unirrigated, has now been brought within the circle of irrigation by means of repartition. In addition to 214 acres thus irrigated, 470 acres which were formerly uncultivated, since it was not worth while to attend to remote and scattered plots, have now been cultivated, and will be assessed at the next settlement. At the present rates of revenue, and without allowing for a possible increase, the addition to the irrigated and the cultivated area will yield a revenue of Rs. 1,552-12, and the cost to Government will therefore be recouped in 3½ years. It is, however, probable that more wells will be sunk, and the gain to Government will be greater and more rapid.

It is interesting in this connection to note the cost in Japan. The Japanese Year Book for 1924-25 states that by the end of the year 1922 consolidation (there called adjustment) had been carried out in $1\frac{1}{2}$ million acres out of 14 million acres with which it was intended to deal. The actual area had been increased in the process from 1,471,000 to 1,540,000 acres in consequence of the abolition of needless field boundaries. The total cost was Rs. 26,40,00,000 or no less than Rs. 176 per acre. Experts are trained and maintained by the Japanese Government, and the undertaking is financed by loans from the mortgage bank. The Year Book does not, however, make clear what proportion of the total cost is borne by Government, and what by the landowners. Obviously both parties are considered to profit materially from the adjustment. It is estimated to enhance the yield of crops by 15 per cent., while bringing 3 per cent. of new land under cultivation.

An inquiry into the cost of consolidation in Norway and Sweden in 1924 led me to the opinion that the cost to Government in Norway was about Rs. 2-8 per acre, and the cost to the landowner about Rs. 1-4, while in Sweden the landowner contributed roughly Rs. 2 per acre and the Government Rs. 2-8 or Rs. 3. In both these countries, as in Japan, a majority is empowered by law to coerce a minority, whereas in the Punjab the time and labour spent on an unsuccessful attempt at repartition are lost to us. The landowner in the Punjab incurs no expenditure at all in the proceedings.

It is perhaps unnecessary to explain to Indian readers the value of consolidation of holdings. Its desirability is admitted, argument being directed only towards the most practicable method of carrying it out. The advantages already secured in the Punjab are conspicuous. No exact record of new cultivation or new irrigation up to date has been maintained, but the repartition of 21,000 acres in the single year 1925-26 led to the breaking up of 1,300 acres of new land and the extension of irrigation to 1,600 acres. The addition to cultivation represents partly a number of small plots, which were formerly disregarded by their owners as being too minute or too remote to receive attention, and includes also a certain area of common land now divided among the owners. There is an evident tendency to demand the division of the common land, since the repartition affords an opportunity to each owner of combining his share in the common land with his original holding as now consolidated. It may be argued that division of the common land has its disadvantages, but under the present conditions of Punjab agriculture I myself am quite impenitent as to this policy. Common land is only valuable for grazing, if it is controlled by a responsible body and if the number of stock upon it is limited to its capacity. Such control and limitation is nowhere found in villages of the Punjab which are owned by small peasant proprietors. The grazing ground is overloaded with worthless cattle, and it is in every way better to divide it up and make each cultivator realize that he must feed his own stock. He will then perhaps cease to maintain his more worthless animals. Moreover, the dung dropped on a common pasture in level country is entirely lost, and it is only where the drainage of the pasture falls

on to the cultivated land at a lower level that the maintenance of a large herd has any value.

The increase in the area of irrigated land is due partly to a more economical use of canal water, which is estimated to do 25 per cent. more duty after consolidation than before, partly to location of fields, which were formerly scattered and dry, on the same well as the previously irrigated fields of the same owner, and partly to the sinking of new or the repairing of old wells. One hundred and eight wells were either repaired or newly sunk in the 12 months ending with July 1926, in those villages only in which new societies were registered. Other wells will be sunk and repaired in the same villages in future years, and wells were sunk or repaired in villages in which work was completed in previous years. No record of the latter is available. It is interesting to observe that a cultivator will sometimes accept unirrigated land in one place in exchange for a number of scattered fields on different wells. In the past year, for instance, a cultivator surrendered three acres irrigated by canal water, taking in return nine unirrigated acres, in which he is preparing to sink a well, and there are instances in which a similar exchange has been made at an equal rate of acre for acre. Three cultivators also installed small pumping plants on their wells during the past year, the supply of water being found inadequate for the new area brought within their reach.

Improvement of agriculture is general, where holdings have been brought together. New ploughs and other implements are used, new crops or new varieties of an old crop are sown, sand is removed from light soil, and planting of trees or reeds is carried out. The Agricultural Department has wisely concentrated its efforts in a number of villages where consolidation has been effected, realizing that cultivators who will risk their land—their most precious possession— in so novel a manner will be willing to accept new doctrines from them also. One or two villages in Sialkot and Jullundur have been converted wholesale, every cultivator using a Meston plough, the wheat seed recommended by the department and the methods of cultivation and interculture which they think adequate. The result is a general increase of rents and together with this a general contentment among the tenants. Take two instances at random : the share of produce paid by a tenant of five acres in Gurdaspur has risen from Rs. 100 to Rs. 150, and an absentee owner of another small area receives 80 maunds of wheat instead of 55. A tenant can naturally cultivate better a holding which is conveniently situated in one or two blocks than if he had to travel from end to end of the village in search of each field. He willingly pays a higher rent, and the share which he retains for himself is nevertheless of greater value.

Causes of quarrel and litigation are at the same time reduced. Civil suits and revenue proceedings for partition naturally lapse when the boundary rights to which they refer are swept away by a general reallotment. A local authority has had occasion to observe that a cattle pound in Gurdaspur District may have to be abolished on account of the decrease in cattle trespass. As in Japan the removal of field

boundaries increases the total area of the village, paths are provided, giving access to each man's holding, and the general economy of time and labour will readily be understood. It is by no means uncommon for an owner to find his 30 or 40 blocks united in one large holding, and there is an instance of a landowner whose land, formerly scattered in more than 200 places, has all been brought together in one block.

There are a few cases of enclosure, one owner in Gurdaspur having grown a thorn hedge round his 200 acres, while another has built a mud wall. Owner-cultivators, who leave the village site and build their houses on their land, are becoming fairly numerous, and where cattle theft is not unduly rife, this tendency will no doubt be accentuated. It would perhaps become more rapid if the best method of enclosing land could be decided. Prickly pear encroaches on the crops, mud walls collapse in heavy rain, thorn hedges require frequent attention, and wire is expensive.

In considering the advantages of consolidation it is important to maintain the distinction between the two evils of fragmentation and subdivision. Subdivision is primarily a consequence of large families, together with the rule of inheritance in equal shares. Subdivision would not, however, lead to fragmentation or the scattering of a holding in numerous small patches, did not each heir insist on receiving an equal portion of each field in every place. Consolidation does not aim at the creation or the maintenance of an economic holding. It is both possible and probable that it will render economic many holdings which in their scattered condition were uneconomic, but does not and should not concern itself directly with the size of holding, and any criticism which aims at showing that the holdings so consolidated will again be subdivided by the grandchildren of the present holders is entirely irrelevant. I am myself entirely incredulous as to the economic holding, which I regard as a myth. Families can be and are in some countries maintained in comfort on a quarter of an acre, if the cultivation be sufficiently intensive and capital be properly used. The remedy for subdivision is intensive cultivation, but the primary object of consolidation is not the prevention or cure of subdivision but the cure of fragmentation by bringing the fields of each holding together, whereby intensive cultivation can be practised if the cultivator wishes to do so.

No legislation on this subject has yet been passed in the Punjab, and the need for legislation is at present only felt with regard to minor difficulties. It would be convenient if provision were made that in the event of a suit being brought by a minor on attaining his majority, by the reversioners of a widow, by an absentee on return to his home, or by a mortgagee who had refused to answer a reference made to him by the consolidation society, the plaintiff, if successful, should not be entitled to upset the entire work of consolidation, possibly carried out some years before and accepted by the whole community, but should be given compensation in cash for any wrong which he had suffered. It is, however, probable that a reasonable civil court would in any case act on these lines. It is also probable

that the fears expressed by the class of occupancy (hereditary) tenants in the Punjab, that their reversionary heirs may lose their right of succession if the holding has been exchanged in a consolidation proceeding, are in reality groundless, but since assurances by high authority have not been able to allay these fears, the advisability of making a small amendment in the Punjab Tenancy Act is being considered. The model bylaws of these societies have now been so amended that the exchange of possession is to be permanent. The old bylaw providing for a reversion to the former status after four years has been found unnecessary. The new bylaws also bind a member to submit to the decision of the society in general meeting any partition or redistribution which may become necessary or be contemplated in respect of the land once consolidated, but though such a pledge may be effective against the original member of the society, it is not clear how it can be enforced against his successors. It should, however, serve a useful purpose by organizing public opinion in favour of united holdings.

As mentioned above, the power of compulsion given by the bylaws has never been used, and we still refrain from any attempt to use it, so long as the illiteracy and shortsightedness of the rural population leave dangerous power in the hands of a grumbler. We prefer to lose our time rather than risk the evil effects of unjustified criticism. In one case a single malcontent, whom no persuasion could induce to withdraw his objection, was left out of the society, and all the rest of the land in the village was redistributed. He is now our best propagandist in the neighbourhood, since his land is left for ever scattered in tiny patches on all sides of the village, while his neighbours rejoice in convenient and combined blocks. His lamentations are of great value to the movement, but we are unable to help him, since it would be necessary to break up the entire consolidation which has been carried out. The map illustrating his position and that of his neighbours repays examination. In my opinion this policy of leaving out objectors might be followed more frequently; our work in one village was spoilt by a single objector out of 264 persons.

It should be noted that compulsory power is given to a greater or less majority of the persons having an interest in the land of the village, in England, France, Germany, Holland, Japan, Norway, Sweden and (pre-war) Russia. There are no doubt other countries of which the consolidation law has not come to my notice. The recent (1925) Dutch Law provides for a local committee and a provincial committee, which in consultation with the owners will draw up a scheme of valuation and a plan for reallotment. An appeal to higher authority is allowed in certain contingencies. Compulsory power, however, in a proceeding of this kind must be somewhat summary if it is to be effective at all, and I find in Norway that the liberal right of appeal not infrequently results in delaying the consolidation for five or six years, and thereby adding considerably to the expense. It cannot be doubted that in view of the tendency of Indian landowners to engage in litigation the result of using compulsory power in this country, and of granting the inevit-

able appeal to the civil or the revenue courts, would be equally undesirable as regards both expense and delay. The Danish Government has adopted in its newly redeemed province of North Slesvig a method of voluntary consolidation which closely resembles the co-operative consolidation of the Punjab. Facilities are offered by the State but no compulsion is used, and it is left to the educated and progressive farmers of the province to engage their own surveyor and submit their own map of reallotment for record with the revenue authority. The Punjab cultivators leave no doubt as to their disapproval of any suggested transfer of consolidation duty to a revenue authority enjoying compulsory powers, and it is hard to see how comparatively low paid subordinates could be restrained by the most upright and strenuous superior staff from misusing the opportunities open to them in a matter of such vital importance to the peasant proprietor.

RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, DR. J. T. EDWARDS ; *Secretary for Publications*, MR. S. K. SEN).]

IX. COCCIDIOSIS WITH PARTICULAR REFERENCE TO BOVINE COCCIDIOSIS AND ITS SIGNIFICANCE AS AN INFECTION OF CATTLE IN INDIA.

BY

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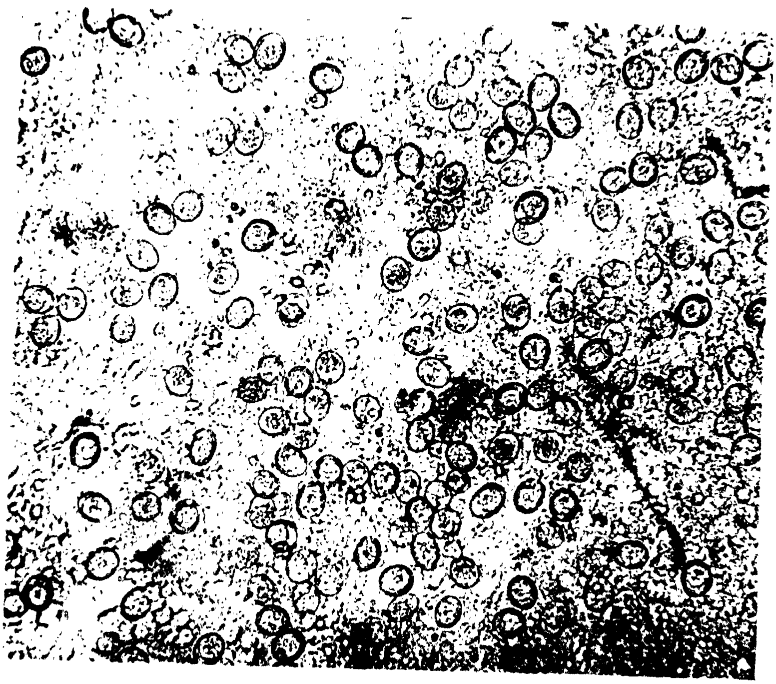
THE coccidia are microscopic organisms belonging to the Order Sporozoa of the Protozoa. As is well known, the Order to which they belong embraces also a number of other important parasites of man and animals, including the causative organisms of malaria of man and " piroplasmosis " of animals.

In a great many of the sporozoa two distinct stages occur in the life-cycle : one of these is spent in the animal host whilst the other takes place in the vector, or transmitting agent, such as a tick or a fly. But in the case of the coccidium one stage is spent in the animal, and the other in the outside world.

The life-cycle of the coccidium within the animal is a complicated one which results finally in the liberation of a very resistant body, the encysted egg or oocyst (Plate X). The oocyst must now spend a certain period of time in the outside world exposed to air and moisture, and during this time minute spores are formed within it, which in turn must reach the cells of another animal in order to complete the life-cycle.

In a great number of cases coccidia are parasites of the intestinal tract of animals, and from this position the oocyst is able to escape easily in the fæces to the outside world and the spores can also readily gain entrance to other animals in food or in drinking water. Invasion of the animal body by coccidia is not, however, restricted to the intestine. The urinary tract has also been found to harbour these parasites. Infection of the kidneys and ureters in birds is known, and invasion of the bladder has been reported in cattle. The liver is involved very commonly in rabbits, but oocysts that develop in this organ are believed to be unable to escape from it, and

PLATE X.



OOCYSTS OF BOVINE COCCIDIA. (× 288).

so to complete their life-cycle. The same phenomenon is known in the case of liver abscess in man, caused by amœbæ.

Interest is centred for a number of reasons upon the stages in the life-cycle that takes place in the outside world. The oocyst, as it occurs in the fæces of animals, is distinctive and easily recognizable, and it is upon the demonstration under the microscope of this body that a diagnosis of infection in an animal is usually made. The earlier developmental forms, while within the animal cells, are more difficult to find or to recognize with certainty, for indeed in many cases the complete life-cycle has not yet been fully worked out. On the other hand, it is not a difficult matter to follow completely the changes that occur within the oocyst outside the animal body. The division into spores can be watched in the laboratory, and upon the characters of this division the species of coccidia are differentiated, for several species of the parasite are recognized.

Coccidia have an exceedingly widespread distribution among animals, including man, most of the domesticated animals, carnivora, birds of all kinds, and even reptiles and still lower forms of animal life, extending to the invertebrates. It is of interest that intestinal coccidia have probably never yet been found in the Equidæ—a division which embraces horses, donkeys, mules, etc. Recently, an examination of a small number of various animals has been undertaken at the Muktesar Institute, and infection has been found to occur in bovines, buffaloes, sheep, goats, ducks, geese, turkeys, and in domesticated and wild pigeons.

The occurrence of coccidium was first recorded in the rabbit, and when infection of other animals was later detected, the rabbit coccidium was frequently incriminated as being responsible for infection in these animals also. Coccidia of both man and cattle have been thus stated to be identical and to have originated from rabbits. This supposition is now known with certainty to be without foundation, and the coccidia do not appear to be an exception to the general principle of parasitism and host-speciation, namely, that each kind of animal harbours its own species of parasite.

In what appears to be a most common form of coccidiosis infection of animals, no noticeable effect upon the host is produced. The healthy animal body is usually able to support the parasites and probably to limit their multiplication and thereby prevent widespread invasion of cells.

This appears to be the case invariably in infection of the intestines of man, for no authentic example has yet been reported where any symptoms or lesions are known to have been due to the effects of coccidia. This would appear to be the case also in pigs, whilst, again, a very large number of dogs and cats are infected by these parasites, and it is probably rarely indeed that any ill effects result directly from the infection. On the other hand, coccidia are capable of inducing a very severe form of intestinal disturbance by rapid and widespread invasion of cells lining the intestine, and this may result in outbreaks of disease among certain animals and cause a large number of deaths. Outbreaks of this nature are illustrated in rabbits.

It would appear to be a difficult matter to find an adult rabbit free from coccidiosis, and indeed severe infection is quite commonly seen which nevertheless may still appear to cause no ill effects. Yet in other cases the disease may wipe out the entire rabbit population in a locality, and this disease forms therefore one of the greatest obstacles to the successful raising of these animals on a large scale.

The extent of incidence of the disease amongst rabbits in India will be realized from the fact that during two years and a half (1922-24) at the Muktesar Institute, out of 1,967 *post-mortem* examinations made upon rabbits, only in 349 were no coccidia detected, *i.e.*, over 83 per cent. were certainly infected. Later, when a special concentration method for the detection of very mild infections was adopted, in a period of just more than one year, out of 855 consecutive *post-mortem* examinations, only in 5 (*i.e.*, in less than 1 per cent.) were no coccidia demonstrated.

A similar condition appears to exist in sheep, for in certain places, where careful examination of large numbers of apparently healthy sheep has been undertaken, infection with coccidia has been found to be almost invariable. It has been recorded, however, for example in Egypt, that severe mortality has been found to be due to the effects of coccidiosis. It is, however, amongst birds probably that coccidiosis is found to occur in its severest form. Although, again, an exceedingly large number of all kinds of birds harbour the infection without any noticeable ill effects, yet very severe epizootics have frequently occurred causing enormous mortality. These outbreaks have mainly been observed in game birds, including grouse, pheasants and partridges, and a mortality of 60 to 70 per cent. or even higher has been recorded.

Since 1922 at the Muktesar Institute, a study has been made of coccidiosis as it affects cattle in India. This disease appears to have a peculiar distribution in that it has been reported most frequently in mountainous or hilly regions. The reason for this is probably the existence of moisture conditions in these regions necessary for the development of the oocysts in the outside world. The oocysts of many animals, for example those of the rabbit, will undergo development readily in a fairly abundant supply of moisture; yet if a layer of more than about one centimetre of liquid covers them, no development will occur. The moisture conditions necessary for the development of bovine oocysts are still more exacting, for although they require a certain amount of moisture, yet no development will occur if the liquid present is even in slight excess, and at Muktesar it has been found to be very difficult to devise methods to satisfy these conditions. At first sight, this would appear to be a paradox by reason of the occurrence of coccidiosis on hill tops, but in reality these regions are not as dry as it might be thought on account of the escape of water from them. Dew is more abundant in the hilly regions than at lower altitudes, and sheltered damp gullies exist which support a luxuriant vegetation. Regions of this kind are ideal for the development of oocysts on account of the protection from desiccation that is thus afforded. On the other hand, valleys and flat country either allow an excess of water to remain or else are exposed to

greater desiccation, and in either event they are unsuitable for the development of the oocysts. It was in the mountainous regions of Switzerland that bovine coccidiosis was first discovered in 1878. These mountains are covered by snow in the winter months, and on account of the protection and low temperature, oocysts of coccidia are probably able to exist from one year to the next and so to infect the cattle which come up to the mountains in the spring time. Bovine coccidiosis has since been found in a large number of countries, but nearly always it is described as an enzootic disease responsible for a characteristic form of dysentery and resulting in a number of deaths.

A careful search of the available literature has failed to find any record of its occurrence in India. In other countries it has already been recognized by a few workers that an apparent relationship exists between coccidiosis and rinderpest, for in the later stages of rinderpest coccidiosis infection has not infrequently been encountered, and a certain similarity between the symptoms of the two diseases has been noticed. During extensive investigations upon rinderpest at Muktesar, it had been realized that a number of deaths occurred at a late period after inoculation with rinderpest virus, and in many of these cases it was difficult to ascribe the cause of death to the effects of the inoculation. For the reason also that the cattle used in the experiments came from the mountainous districts near the laboratory, the possibility of a complication of rinderpest syndrome by coccidiosis suggested itself. This possibility was borne in mind while undertaking the routine *post-mortem* examination of cattle at the Institute, and on 4th August, 1922, the disease was demonstrated to be present in a bull which had died in the circumstances mentioned. It is of interest that a reason that has been given to explain the failure to detect coccidiosis in India hitherto, is that the cattle fæces in this country are collected and made into cakes for consumption as fuel and that in this way spread of the disease is entirely checked (Baldrey, 1906). The real explanation, however, would appear to be the close similarity between coccidiosis and rinderpest, which undoubtedly exists both in incidence and the character of symptoms and lesions. Rinderpest has so strongly attracted the attention of observers that when deaths have occurred among cattle that have shown symptoms and *post-mortem* lesions characteristic of this disease, such deaths have been invariably attributed to rinderpest.

Following upon the detection of the first case of coccidiosis in cattle at Muktesar investigations that were instituted soon showed that the disease was of common occurrence, particularly among the animals used in rinderpest investigations. It was not, however, until special methods for concentrating the oocysts of the parasite in fæces were utilized, which rendered possible the detection of very mild infections, that a correct appreciation of the incidence among bovines was made. In a paper read before the meeting of the Indian Science Congress held in 1924[1], it was men-

[1] Since published in the *Agricultural Journal of India*, Vol. XXI, pp. 95-100 (March 1926).

tioned that at Muktesar a number of (twelve) healthy young hill bull-calves were specially procured in order to attempt transmission experiments with coccidia, and it was found that every one of the twelve calves was already infected. It has now been established beyond doubt, from the large number of examinations made, that hill cattle in the Kumaon and surrounding districts almost, if not quite, invariably harbour coccidiosis infection. Up to the present time, only a limited number of cattle have been examined in other parts of India, but the results of examination of samples of fæces obtained would appear to justify the conclusion that coccidiosis is very widespread in the plains of India also.

Although in the literature upon coccidiosis of cattle it is almost always described as an epizootic or an enzootic disease, yet not infrequent mention is made of concurrent infections, such as piroplasmosis, pneumonia and other diseases, the most important of these infections mentioned being undoubtedly rinderpest. In another paper of this series the importance of the relationship between coccidiosis and rinderpest has been discussed.

In other countries a definite train of symptoms and certain *post-mortem* lesions have been described. The experience obtained at Muktesar is that although these symptoms and lesions may be shown by an animal suffering from coccidiosis, yet severe and even fatal affection may occur in which little or nothing characteristic can be found. From the symptoms observed elsewhere the disease has received the name of "red dysentery." This is based upon the fact that a variable quantity of blood mixed with mucus is passed in fæces. Although in every case of severe coccidiosis at Muktesar the presence of blood in the fæces has not been seen, yet in the very large majority of cases it has been noticed, and its occurrence would appear to be the only really characteristic symptom shown. The clinically recognizable disease of coccidiosis in cattle then is a true dysentery, which ends either in death or recovery after a short interval of a few days, and it is accompanied by a very severe wasting and debility. A certain diagnosis can only be made by the microscopic examination of the fæces for the oocysts at the height of the malady.

The most striking feature of the *post-mortem* examination of an animal that has died of coccidiosis is the frequent absence of naked eye lesions, in spite of, perhaps, a history of severe intestinal disturbance. Infection by coccidia is almost entirely limited to the mucous membrane of the large intestine, and in spite of the fact that large quantities of blood may have been passed in the fæces by the animal during life, very little alteration in the intestine to account for this may be seen. This is due to the fact that escape of blood takes place from a large number of very minute ulcers, which may be even microscopic in size, or only just appreciable to the naked eye as very small, apparently insignificant, "blood spots" upon the lining of the intestinal wall.

Methods devised to prevent the spread of coccidia have been recommended, but in view of the fact that latent infection already exists in probably nearly all cattle in India, these methods are of little practical value in this country. Unfortunately

also, up to the present time, all types of coccidia have shown themselves to be remarkably resistant to every form of curative treatment that has so far been tried.

Further investigation is needed in order to understand more fully the circumstances which allow this latent and usually harmless infection to assume the characteristic of a severe and sometimes fatal disease.

FODDER FAMINE RELIEF IN THE UNITED PROVINCES.

BY

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THE usual cause of any widespread scarcity in food for human beings and cattle in the United Provinces is deficient or unfavourably distributed rainfall. Local scarcity may, sometimes, be caused by excessive rainfall or by exceptional climatic conditions as frost and windstorms. Lack of rain is, however, the main cause of fodder shortage. Rain in excess may lead to the destruction of fodder producing crops, but the deficient fodder supply caused thereby, is often partly made up by additional grazing. Exceptional climatic conditions may lead to scarcity of fodder, at some time or other, in practically every district of these provinces. Insufficient rainfall, however, is the most frequent cause, and scarcity arising therefrom recurs most often in a certain fairly well-defined tract. The famine relief reports of the last five famines show that relief operations were invariably necessary in certain parts of a tract lying along side the river Jumna, stretching from the Muttra District on the west to Mirzapur District on the east and including usually the whole of Bundelkhand, which was usually to a large extent severely affected. With the exception of Bundelkhand, this tract includes parts of the following districts: Muttra, Agra, Etawah, Mainpuri, Cawnpore, Fatehpur, Allahabad and Mirzapur. These districts are partly protected by canal irrigation, and many of those parts not so protected are fairly freely supplied with wells, which, when required, may be made an efficient source of water for irrigation. The canal irrigated area in Bundelkhand is small, and the supply of water dependent, to a considerable extent, on local rainfall. The wells are very much less efficient, and in years of deficient rainfall may hardly produce sufficient for drinking purposes for men and animals.

In years of normal rainfall the large grazing tracts of the Bundelkhand districts produce a plentiful supply of grass for grazing and a considerable surplus which could be stored. The neighbouring districts of the Central Provinces and Central India similarly in years of favourable rainfall produce a large quantity of grass of high feeding value. In years when the rainfall is in defect, however, the supply of grass, both in Bundelkhand and in the grass producing districts which border it on the south, is very defective, and importations of fodder from other districts are very necessary to support the large cattle population which these districts usually maintain. The methods of fodder famine relief hitherto adopted have been—

(1) to encourage the transfer of fodder, such as *bhusa* (straw-chaff) and *kadbi* (dried sorghum stalks), from districts where there is a surplus to districts

where the supply is in defect, by giving railway concessions to private contractors to undertake the purchasing and distribution of fodder to affected areas ;

(2) by the supply of grass by Government, cut from Government forest areas and delivered to the affected areas at concession rates ;

(3) by the giving of takavi advances to those affected, for the purchase of fodder.

With regard to supply of fodder, the first method is effective when the pecuniary condition of the cattle-owners is such that they are able to purchase the fodder supplied by the contractors. When this is not so, as was the case in the Bundelkhand districts in the 1913-14 famine, the supply of fodder by Government at very cheap rates is an absolute necessity. The following statement shows the cost to Government of these operations during the 1913-14 and the 1918-19 famines.

	Private contractors		Government forest supply		Other sources as traders and Central Provinces Administration	
	1913-14	1918-19	1913-14	1918-19	1913-14	1918-19
	Md.	Md.	Md.	Md.	Md.	Md.
Quantity of fodder supplied .	23,24,893	4,17,000	14,41,400	8,94,617	1,83,000	30,000
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Amount paid as railway concession by Government.	10,00,000	82,000	..	..	..	..
Total cost to Government .	..	..	13,95,144	13,36,731	2,58,500	30,000
Cost to Government per maund.	0 7 0	0 3 2	0 15 9	1 8 0	1 6 6	1 0 0
Total net cost of fodder relief operations.	21,00,000	11,00,000	..	..	..	..

It will be seen that the total cost to Government after taking account of all receipts for fodder paid for, was 21 lakhs of rupees in the 1913-14 operations and 11 lakhs in the 1918-19 operations. In the 1913-14 operations 23 lakhs of maunds of fodder were imported by private traders at concession rates on the railways, which cost Government 10 lakhs of rupees, *i.e.*, roughly As. 7 a maund, and 14 lakhs of maunds of hay were imported at roughly Re. 1 per maund from Government forest areas ; and in 1918, 4 lakhs of maunds of fodder were delivered at concession rates by private contractors which cost Government Rs. 82,000, *i.e.*, As. 3-2 a maund, and roughly 9 lakhs maunds of grass from Government forest areas at a net cost of 11 lakhs of rupees, *i.e.*, Rs. 1-8 per maund. The supply of fodder by private contractors consisted chiefly of *bhusa* and *kadbi* and in feeding value must have been very much higher than that of the grass from Government forests. The relative low cost

per maund incurred by the concession rates on account of this supply made by private contractors, and the superior feeding value of this fodder indicates that, when the purchasing power of the affected areas permits, this method as a form of relief is more effective and economical than the supply of forest grass.

An examination of the figures given in the famine relief reports giving the cost of the various operations involved in the supply of forest grass shows the large proportion which is absorbed by transport and by those operations as baling and pressing, etc., which are necessary to keep down the cost of transport to make transport of fodder by railway at all practicable. The resolution on the Administration of Famine Relief in the United Provinces in 1918 contains the following statement (Appendix (*b*), page 15) :—

Statement showing the expenditure involved in the supply of fodder from the Forest Divisions, Eastern Circle.

	Per maund Rs.	A.	P.
Cutting, carting, baling and loading	0	9	0
Freight	0	7	8
Ties	0	3	4
Establishment	0	0	7
Press	0	0	6
TOTAL	1	5	10

That is, Rs. 1-5-10 represents the cost of delivering each maund of forest grass to distressed areas.

The actual cost of production of this fodder as represented by the rent of the land on which it was grown, *i.e.*, probably about anna one per maund, *plus* the cost of cutting—two annas a maund—could not have exceeded As. 3 a maund. The cost of delivery, therefore, was about seven times the cost of actual production. The reports do not show to what extent the price of fodder supplied by contractors was increased on account of the cost of transport. In 1913-14, Government paid As. 7 per maund on this account to railways as compensation on account of the concession rate. This does not include the whole of the cost absorbed by freight, as to this must be added the amount paid by the contractor. In 1918, however, the amount paid by Government to compensate railways on account of the concession rates was As. 3-2 per maund, which seems to indicate that supplies of fodder were drawn from districts near to the affected areas. These figures all go to show how expensive the transport of fodder may become, and how easily the cost of fodder can be doubled as soon as transport becomes necessary. The low value of fodder in relation to its bulk makes it a very unsuitable commodity for transport over long distances. With commodities like coal or oil, which are to be found only in certain

special areas, transport must necessarily form a considerable part of the cost of production. With fodder, however, which can be produced practically anywhere in the United Provinces, this tremendous increase in cost on account of transport seems unnecessary.

If we consider the large number of cattle which are maintained in even those districts which are liable to occasional fodder famines, the cost of maintaining them on imported fodder for only six months and on the minimum ration required, would, at the above rates, amount to a tremendous figure. Hitherto the aim of fodder famine relief operations has been to husband and keep alive valuable and necessary animals, such as working bullocks, and let those of smaller value, which would not pay for this high cost of stall-feeding, fend to a great extent for themselves. Cattle census returns, following famine years, usually show therefore a substantial decrease in breeding and young stock. This, coupled with the large demand for takavi advances for the purchase of cattle, seems to indicate that the fodder relief measures are not wholly sufficient to prevent considerable loss, although they may attain the main object of keeping alive those cattle which are absolutely necessary to enable cultivators to make a recovery when better conditions prevail.

Although the supply of grass from Government forests is a necessary measure under certain circumstances, it is open to criticism on the ground that the expense involved in freight and transport is out of all proportion to the value of the fodder transported. As has been pointed out in the reports on famine relief operations, grass from the forests, particularly from the north-eastern districts, becomes very coarse and fibrous if not harvested immediately after the rains. As that is not always possible, it is very questionable whether the hay made from such grass has a very high feeding value. If cut late, as in December and January, these forest grasses must, in fact, make hay of particularly low feeding value. These grasses are valuable from the point of view of cattle-breeding because they produce a strong growth of nourishing and palatable shoots during the hot weather, after the grass produced during the monsoon has been burnt in about January and February. It is this summer grazing which makes forest areas valuable as pastures and not the coarse grass produced during the rains. Nevertheless under famine conditions it can be understood that cattle will readily eat such grass and will manage somehow or other to keep alive.

The ready response made by contractors to supply fodder to affected areas when encouraged by a concession rate seems to suggest that fodder famine relief measures could be further developed along these lines. The supply of grass from Government forests is limited in amount, and the report of the 1913-14 famine shows that the limit was nearly reached in regard to the Eastern and Western Forest Circles. In itself it does not form a basis for the development of a scheme for fodder supply, and it is very questionable when one considers the cost of transport, both from the forest to the railway, and on the railway itself, whether the results obtained are commensurate with the expenditure involved. Since the area which is most

frequently affected consists of a fairly well-defined tract, the idea suggests itself that if by some means the growing of fodder can be encouraged in certain districts of this tract to ensure the production of a certain excess quantity every year, it is possible that these districts which are usually more frequently affected by scarcity may become to a considerable degree famine-proof in regard to fodder. A scheme which would ensure the production of a definite amount of fodder in years of deficient rainfall, and which would increase the quantity produced in the years of normal rainfall by the like amount must eventually lead to the accumulation of reserve stocks. It is a noticeable fact that in periods of scarcity villagers are induced to sell fodder even though they may require it for their own cattle later. In normal years the price of *bhusa* and *kadbi* being much lower, there is a tendency to store fodder. In order to make local reserves, therefore, it is essential that the price of fodder be kept as low as possible. Accumulations of stocks of fodder, unlike increased facilities for grazing, do not tend to rapid increase in numbers but usually result in better methods of stall-feeding. A suggestion is here put forward, which, it is thought, would, if put into effect, encourage the production of a certain amount of fodder every year in or near districts which are likely sooner or later to be affected by fodder shortage. As has already been emphasized, fodder should be produced as near the place of consumption as possible, and transport should be reduced to an absolute minimum. The production of fodder crops can be assured only if the crops are sown under irrigation. In the famine tract, which we have been considering, irrigation can be carried out to some extent from a canal supply but for the most part will be dependent on wells, except as regards Bundelkhand, where in years of deficient rainfall the wells cannot be used economically for irrigation purposes.

The following statement shows the approximate cost of production of *juar* fodder under well irrigation in a year of moderately unfavourable rainfall.

The cost of production of one acre of summer fodder crop (juar) under well irrigation.

	Rs.		Rs.
2 pairs of bullocks at Re. 1 per pair per day	2	will irrigate from a well of average depth 1 acre in 3 days.	
and 4 men at As. 8 per day	2		
i.e., cost of one irrigation	12		
On an average 3 irrigations will be required			36
Two ploughings at Rs. 2 each			4
Manuring at Rs. 12 per acre, $\frac{1}{3}$rd debited against this crop			4
Sowing			2
Seed			2
Rent			12
			60
Harvesting 120 maunds dry fodder at As. 2 per md.			15
			75

One hundred and twenty maunds of fodder are produced at a cost of Rs. 75, *i.e.*, As. 10 a maund. Probably a cultivator can produce *juar* fodder at a smaller cost

than this, but, for the purposes of this discussion, the figure is near enough. It will be noticed that roughly half the cost is on account of irrigation. The production of a similar crop under canal irrigation would, of course, be very much less.

At present the area of summer fodder crops sown under irrigation in these provinces both in canal-irrigated tracts and in well-irrigated tracts is very small. Summer fodder crop production is more widely practised in canal tracts in the Punjab than is the case in these provinces, and in villages in canal-irrigated tracts in that province considerable stores of fodder are to be seen.

There is no doubt that the average cultivator who is also the owner of good cattle would, if he could foretell an absolute failure of the rains, make a point of sowing a certain area of summer fodder crop under irrigation. Unfortunately it is only possible to know for certain that the rains have failed when it is too late to make such provision. The average cultivator prefers to gamble on a favourable monsoon rather than incur the risk of spending money on irrigation which would be partly wasted should it be followed by a favourable monsoon. Some inducement, therefore, is necessary to encourage the cultivator to take this risk.

It is thought that a subsidy of Rs.10 per acre would be ample inducement to cultivators to sow high yielding summer crops under irrigation. If such a subsidy resulted in crops averaging 120 maunds per acre the cost to Government would be As. 1-4 per maund of fodder produced. In each of the last two famines about 10 lakhs of rupees were spent in the supply of forest grass. On the assumption that a fodder famine can be expected every five years and assuming that this amount is distributed over five years to finance a subsidy scheme for the production of fodder, as described above, it will result in the production of 24 lakhs of maunds of superior fodder in each of the five years as compared with roughly 9 lakhs of somewhat inferior hay made from forest grasses, which cost roughly 10 lakhs of rupees to produce in a single famine year. If when the first famine occurs the scheme is in its fifth year of operation there will be for distribution that portion of the previous four years' production which has been left unconsumed and a portion of the 24 lakhs produced during the famine year. There is no doubt that a considerable portion of this will have been stored by cultivators, and that this extra production will have had some effect in reducing the price of fodder in that locality which in itself will encourage storage and discourage sale. The increased production of fodder in districts liable to fodder famine will result in accumulation of stocks which may be drawn upon by neighbouring districts, should scarcity occur.

A subsidy of Rs. 10 per acre is no doubt a liberal one, and if a cultivator in years of favourable rainfall times his sowings well, only one irrigation may be necessary. The cost of irrigation in such a year will be fully covered by the subsidy. Should two irrigations be necessary the extra fodder which the irrigated land would produce will to a large extent compensate him for the extra expense incurred. In an unfavourable year a third or fourth irrigation will be necessary, but this he will not grudge because his crops will be by this time half-grown and he will not risk the loss

of a good crop for the sake of the extra irrigation when a fodder shortage is imminent.

A SUBSIDY SCHEME IN OPERATION.

Cultivators in districts liable to fodder famine who undertake to carry out the scheme could be given takavi advances to the extent of Rs. 10 per acre of land which they undertake to cultivate for summer fodder crop under irrigation. As regards well irrigation *patwaris* could check and report in September the area of fodder crop cultivated under irrigation and for canal-irrigated tracts the canal zilladars. In the case of land irrigated from canals the subsidy could be greatly reduced. Probably the remission of the canal dues would be sufficient for this purpose.

It is possible that the question of fodder supply is more involved than a perusal of this note would indicate. There are probably many factors and unsuspected difficulties which have not been considered. A full and complete knowledge of the various problems which enter into the question can be ascertained only when efforts are made to tackle some of them practically. If the above suggestion is tried on an experimental scale as I suggest, either it or any other measure which aims at the encouragement of increased fodder production locally, could be attempted, the various problems connected with the question will be considered as they arise, and if the schemes themselves prove impracticable or fail in their results our knowledge of the various factors which affect the question cannot fail at all events to be greatly increased which may lead to the suggestion of more effective schemes at a later date.

CONCESSION IN RAILWAY FREIGHT AND LOCAL SCARCITY.

There is no doubt that the tendency to store and preserve fodder is rapidly affected by fluctuations in the market price ruling locally. If the market price rises above a certain figure there is a strong tendency to sell fodder. Should a local scarcity arise in a particular district, as was the case for instance in Muttra last year (1925), when there was a failure of the *kharif* (monsoon) crop, cultivators disposed of a considerable quantity of their reserve stocks of fodder probably to obtain ready money to finance succeeding crops. The price of *bhusa* in Muttra city rose and cultivators were induced to dispose of much of their stock in this and other local markets. The reserve stocks of fodder of the district must have been greatly depleted.

Although the rise in the price of *bhusa* was high enough to encourage local cultivators to sell their stocks, it may not have been high enough to encourage the import of fodder from distant districts where there was a plentiful supply.

It is possible that if a small concession in railway freight had been granted the importation of stocks from more distant districts might have been encouraged, which would have been sufficient to keep down the price of *bhusa* or would have prevented a rise such as entices local cultivators to dispose of their stocks with absolute disregard of the future. In this again the required information can be obtained only by an actual trial.

A SHORT NOTE ON THE FOOT-ROT DISEASE OF *PAN* IN THE CENTRAL PROVINCES.

BY

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Pan (*Piper betel*) is cultivated in many districts of the Central Provinces such as Drug, Mandla, Ramtek etc. This is a very important garden crop which brings not only much profit to the owners but its cultivation is also responsible for much employment of agricultural labour. Its cultivation is unfortunately a close monopoly of the Barais who invest it with a great deal of sanctity and religious superstition, with the result that one who is not a Barai is hardly tolerated inside the garden and any reliable information regarding the cultivation or health of this very important and lucrative garden crop is scarcely available, and its improvement is practically impossible. Its present cultivation is on the same lines as was followed by the remote ancestors of the present Barais, *pan*-growing being more or less an hereditary occupation. The general methods of cultivation are practically the same everywhere in the Central Provinces, except that in some districts the life of the *pan* garden is five years, whereas in others it is only three. They are always kept so damp and moist that once a moisture loving organism which can be parasitic on *pan* vines gets introduced, it is found to flourish at the expense of the host. In 1923 reports were received from Drug District that *pan* gardens there were almost completely wiped out by a disease. There is a large export of *pan* leaves from this district and that year the export was almost negligible. In 1924 similar reports were received from Ramtek Tahsil; the financial loss to the Barais was estimated locally over a lakh of rupees; the once flourishing *pan* gardens were allowed to run weedy and were completely neglected because the few living *pan* plants hardly justified the cost of upkeep. The big army of agricultural labour that was in normal times employed in these gardens was put out of work. The intensity of the loss caused by the disease can be well realized from the fact that in a local paper the Barais, who are as a class very orthodox and conservative, had offered a reward of Rs. 500 to anyone who would cure the disease. But it is a matter of regret that inspite of this serious loss caused by this epidemic, the Barais did not co-operate with the local Agricultural Department in investigating the cause of the disease and in finding remedial measures, though some of the local people did their best to influence the Barais to co-operate with the department. The disease is reported to cause most damage to vines during the wet months of the

year. In winter the virulence of the disease is decreased and in summer it practically disappears. The presence of the disease is first noted by the drooping of the upper and tender parts of an infected vine. They become limpid and they look as if the plant was suffering from want of water. The whole plant rapidly droops, loses its bright green colour, turns pale yellow and ultimately brown. The leaves lose their turgidity and shrivel. If a dead or dying plant be examined it will be found that its basal portion has lost practically all its soft tissues, it is in shreds and can be easily pulled out of the ground, the roots having been completely destroyed.

At this stage perhaps minute black and bristly or pink and oily pin-heads may be visible on the diseased and dead parts of the plants ; these are the acervuli of the *Colletotrichum* stage, or of the *Glœosporium* stage of *Glomerella cingulata*—the perfect stage having been found both in cultures and on dead plants. In the majority of cases *Colletotrichum* and *Glœosporium* have been isolated from diseased plants, but these fungi have not been found to produce the disease when healthy plants have been inoculated. In the laboratory of the Imperial Mycologist, Pusa, these fungi have also been often isolated from diseased *pan* plants from Bengal, but there also it has not been proved to be parasitic. In some cases, *Rhizoctonia destruens* has been found from diseased plants along with *Colletotrichum* and *Glœosporium*. This fungus is also not considered to be the chief cause of the disease which appears in an epidemic form in *pan* gardens, though it has been observed to infect some healthy plants. The real cause of this virulent disease which appears in an epidemic form is a *Phytophthora* as has already been reported.[1] The infection spreads from the ground to the plant. At the collar or a little below it, in the early stage of attack, which is evident by the drooping of the uppermost tender twigs and shoots and by the hanging limply of the upper new leaves which become flaccid and which lose their colour, a brown spot surrounded by a water-soaked ring dirty green in colour is visible ; as the infection spreads the original brown spot turns black and the former water-soaked ring becomes brown in colour and tissues round this brown colour become water-soaked. The infection does not extend beyond more than a few inches above ground level. The roots near the badly infected parts of the vine are practically wholly destroyed. In the case of old creepers the branches which are in contact with the ground show at first small circular or oval brown spots surrounded by a water-soaked ring, these discoloured diseased areas soon increase in size and have the same appearance as the diseased collar of the main stem. In the gardens the badly infected parts of the stem are soft and watery, the cellulose parts of the tissues being very slimy. But in artificial infections in pots, the diseased parts do not always show the rot. The rotting of the tissues may be due to saprophytic organisms. The presence of the *Phytophthora* is not easily to be detected in the dead or dying plants. It seems to

[1] Dastur, J. F. Report of the Mycologist to Government, Central Provinces, for the year 1923-24, Dept. Agri., C. P. and Berar. Report on the Mycological Research for the year 1923-24, p. 21.

live only in the healthy tissues of the host and once they are dead or almost dead this fungus is not to be found in them. *Glomerella cingulata* then follows in the wake of *Phytophthora* and spreads rapidly in dead and dying parts of the plant. The presence of this *Phytophthora* can only be detected in the recently infected tissues of the plant. If the parts of the stem showing early signs of infection be microscopically examined, hyphæ of the *Peronosporaceæ* type can be detected between the cells, especially by the use of suitable stains. Pure cultures of *Phytophthora* can be obtained from these newly infected parts of the plant. Inoculations of rooted plants in pots have produced the disease typically. In culture media the perfect stage of the fungus has been obtained and the oospores, in size and shape, are similar to those of *Phytophthora parasitica* found on *Ricinus communis* and *Vinca rosea*. The oospores have also been found, though very rarely, in the dead tissues of diseased plants; they may be either inter- or intra-cellular. The cultures produce sporangia, rather sparingly, but not zoospores. The sporangia have been so far observed to germinate only conidially.

Once the real cause of the disease was discovered the next step was to find remedial measures for preventing the disease; for this purpose the scene of investigation should shift from the laboratory to the infected *pan* gardens, where alone remedial measures could be tried and the merits of different treatments judged. Once the vines were infected it was impossible to cure them, as no fungicide could reach the inner tissues of the plants where the parasite does its fell work, so these measures would be necessarily preventive and not curative. For the solution of this problem the co-operation of the Barais was absolutely essential and at first this co-operation was promised and given by some Barais at Ramtek. Since the fungus resides in the soil and the plant catches the infection from the soil by direct contact, disinfection of the soil would perhaps control the disease; treatment of a badly infected garden was naturally out of the question. Therefore soil round newly infected and round healthy lines of vines in an infected garden was sprayed with fungicides; the lower portions of the plants were also sprayed. In conjunction with the disinfection of the soil surface with fungicides the following measures were suggested :—(1) During the wet months, partial removal of the thatching material from the sides and tops of the supports, in order to let in fresh air and sunlight, (2) restricted use of irrigation water, (3) proper sloping of irrigation channels in order to avoid water-logged areas in them, (4) restricted use of oil-cake, (5) the lower shoots of old vines should not be allowed to hang so low as to be in contact with the soil. They should be raised and tied to the supports so that they may be clear off the ground. It seems essential that, at least during the rains, the gardens should be opened out and exposed to sunlight even though thereby the market value of the leaves be slightly reduced, because it is not improbable that dry conditions in the gardens during the wet months would considerably help in controlling the spread of the disease. It is extremely difficult if not impossible to bring home to the Barais the value of dry conditions in the garden, especially during the wet months

of the year. Some of the Barais at Ramtek promised to follow these suggestions but they were not followed. Still the preliminary experiments in spraying the soil round the plants in a garden which was showing early signs of infection gave encouraging results, and it was therefore a great disappointment when it was time to give another spraying with the fungicides under trial, the Barais suddenly refused permission to let us continue the work. The little work that has been done in disinfecting the soil in a recently infected garden gives some hopes of this line of investigation being fruitful, if only sufficient work is allowed to be done.

After a great deal of effort the department has been successful in securing the co-operation of two garden owners at Ramtek who have offered from this year, for a period of two years, the use of two small plots of land where remedial measures suggested above will be tried.

DEVELOPMENT OF THE POULTRY INDUSTRY IN INDIA.*

BY

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At the present moment the position regarding the development of the poultry industry in India is peculiar. Over a very large part of India one of the main problems is that of the complete employment of the rural population for the whole year. This is the case in all the tracts—filling far more than half the cultivated area of India—where there is only one crop a year, and where the land has to stand idle for the rest of the twelve months. In these areas nearly all those who are looking toward economic development are trying to find occupation for the people during the large amount of necessary spare time. Mr. Gandhi trusts to the *charkha* to meet this. Others talk of cottage industries. Others look to large scale industrial development to meet the situation. And probably all are right. But without for a moment pretending that the production and marketing of poultry and poultry products will be an *open sesame* in a very difficult economic situation, I do think that the development of the poultry industry may give some contribution to the solution of the important present problem to which I have just referred.

The fact is that in India we have almost ideal conditions for keeping poultry. This country is the original home, probably, of some of the very best breeds of poultry in the world, of more than one type. The Asil or Indian game is still one of the favourite world breeds and has points which no other possesses. The Chittagong, the Brahmaputra, the Cochin and others also stand high. And yet at present the ordinary fowls seen in every part of India, are miserable undersized birds, giving tiny eggs, and are unworthy of a place among decent poultry except for the one quality of hardiness. Further, the keeping of poultry has tended to become a despised occupation, relegated to the depressed or inferior classes, and hence without much hope of advance.

There is, however, no reason why the quality of the fowls and eggs should be so inferior, or why the keeping of fowls should continue to be a despised occupation. And, moreover, the removal of the prejudices against poultry keeping would introduce a very profitable occupation in the areas which now suffer most from the precarious nature of our climate and where the people suffer most from lack of employment during a large part of the year. I have it from Mr. J. L. Goheen of Sangli,

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* Presidential address to the All-India Poultry Conference, Calcutta, December 1926.

one of the most progressive leaders in improved poultry keeping, that his greatest success in pushing poultry keeping with improved stock, has been in the most precarious tracts where the need for alternative or secondary occupations is most marked.

The immediate question is, therefore, whether, under conditions as they are now, it is possible to make any general and widespread improvement in the poultry and eggs now available, and whether it is possible also gradually to get rid of the prejudice against poultry keeping among the more intelligent classes of the rural population. Of course, the possibility depends very largely on whether improved fowls and especially eggs, produced on a much larger scale than at present, would find a market. And I would like to discuss this very shortly at this stage.

The Indian market for eggs and fowls is practically supplied. The rise in price of both table poultry and eggs has shown that, for a time, demand increased faster than supply, for it seems that the retail prices of these commodities increased for a time faster than that of many other products. But this time has now passed, and it would appear that the Indian demand is supplied. A larger production of poultry and poultry products means now either a widening of the demand here, or the creation of an export trade.

The widening of the demand here will come very slowly and, I fear, cannot be made the basis of a very large, immediate, increase in the production of poultry products. With regard to the creation of an export trade, in eggs at any rate, we are, I feel, in a very different position. The demand of Europe and America for eggs, in the original form or in the dried condition, is very large indeed. What has not been supplied at home has hitherto been largely obtained from China. Conditions in China are at present such that, I think, we may fairly feel confident of being able to capture a part of this egg trade if we in India act at once. If this can be done, it will mean a very substantial new trade at our doors—which will at the same time supply a very valuable rural occupation here, and give us a new outlet for the export of our products.

I must own that my attention was first drawn to the very great importance of making attempts to develop this export trade by Mrs. Fawkes, the very energetic Secretary of this Conference, and she will, I believe, place details before you as to what can be done at present. But it appears that an experimental factory, on a full sized scale, can be established with a capital of about five lakhs of rupees, for the production of dried eggs. There are, moreover, places—the most promising appears to be Chittagong—where eggs are even now available in such abundance and at such a price, as to assure a supply of raw material, and to enable the trade to be tested on a sufficiently large scale to be an adequate pioneer of the industry. I am anxious that the Conference should place on record its opinion on this matter, so that those in authority both in the business and in the official world may know whether this is a matter to be pushed with all the resources at their disposal—as I believe to be the case.

But with the wider market which I believe to be essential but which I think is attainable in the very near future, there appears to be two further needs which must also be fulfilled if the production of more poultry products of better quality is to be achieved. These are, first, a definite organized system, whether in Government or in private hands, by which a regular supply of high quality male birds shall be secured to the rural population prepared to keep them, and, secondly, the provision of adequate means of training men in the best methods of poultry keeping under Indian conditions of climate and other surroundings.

With regard to the first point, I may commend to you the exceedingly successful efforts of Mr. Slater at Etah (United Provinces) in raising the standard of the poultry kept by the people in his district. Such work involves the possession of a flock of high quality fowls of one breed, kept rigidly pure. It also involves some arrangement with the people to whom cockerels from this high quality flock are given, that they should destroy all *deshi* or half-bred cockerels existing or produced among their fowls. If this is secured then it will be found, as has been the case at Etah, that the quality of both fowls and eggs in a district rapidly improves and the number produced per fowl rapidly increases, and soon the question of the larger and wider market arises, of which I have already spoken.

Now I should like to see such a centre of improved poultry in almost every district. I would commend it to all those who have an interest in the economic improvement of the masses. It would seem a valuable line of work for missionary effort, and in a few cases it has been taken up, as for instance in my part of the country, by Mr. J. L. Goheen of Sangli.

Such work as this will have, of course, to depend on at least one nucleus centre of good breeding stock in each province. This may be maintained by the local Government themselves as is intended to be the case by the Government of Bombay at Poona, or it may be maintained by an independent body, like the United Provinces Poultry Association at Lucknow, under subsidy from Government in some form or another. But such a central nucleus of good breeding stock is not likely to *pay* for a long time to come, until the value of high quality stock is more realized than at present, and will hence need a subsidy in some form or another. I trust that such a subsidy will be available everywhere, as the existence of a nucleus centre of good breeding stock in every province seems necessary in any scheme for the wide and general improvement of poultry and poultry products.

But we shall have to secure not only a regular supply of high quality male birds, but also some method of training young men in the best methods of dealing with poultry in this country. And, hence, I admire intensely the work done in this direction by the United Provinces Poultry Association at Lucknow, under the direction of Mrs. Fawkes. While the agricultural colleges throughout the country—and the College in Poona for which I was long responsible as much as any—have tended to neglect this subsidiary agricultural occupation, this little independently organized association has succeeded in maintaining a well-equipped, suitable and

efficient training centre, which might well become a central training place for the whole of India, and might well be supported, as such, by authorities in various parts of the country.

I say this because special training for poultry keeping in India is really needed. Difficulties arise here which do not arise in more temperate climates. The prevalence of vermin, hardly troubled about in many countries, has ruined many a poultry venture. Other diseases are a constant menace. The more delicate breeds are often lost by sunstroke. And as these things exist, it is necessary to know how to meet them, and how to make the best of the fowls under our conditions. Hence a central, well-equipped, training centre will be probably always an advantage even when the provincial agricultural colleges take up training in poultry management as a more important part of their work than at present.

To summarize therefore, I hope, I have shown the great importance of very early special attention being given to the development of poultry keeping with improved stock in most parts of India, as being capable of bringing a distinct contribution to the economic improvement of the population. I have tried to indicate how this is, in some measure at any rate, dependent on the creation of a wider market, which must be sought abroad—and hence involves the preparation of eggs for export either in the fresh, or in the dried condition—a market for which the opportunity appears to exist at the present moment.

Again, I have tried to show how the exploitation of the field depends on the extension of the keeping of improved fowls and hence the increase of improved products, which is dependent again on the existence of flocks of highly bred, first class fowls in every province and ultimately in every district. This again means adequate means of training in the best methods of poultry keeping, for which a central training centre possibly at Lucknow, and provincial training centres at the various agricultural colleges appear to be indicated.

Before I close, there is one other aspect of the subject of poultry development to which I would like to refer. At present, from investigations made in Bombay, it would appear that there is no product in which the producer is more at the mercy of the middleman than he is in the marketing of eggs in the big Indian cities. This can only be met by co-operative effort, and efforts are being made in this direction in Western India as well as elsewhere. The trade is, however, a difficult one—but success is reasonably certain if it is fully studied beforehand, if the attempts be on a large enough scale, if the grading of the eggs is an essential part of the scheme, and if the importancé of marketable eggs being infertile, is fully realized. I would commend this line of advance to those who are really interested on the one hand in the economic improvement of the rural population, and on the other in the development of poultry in India.

I have to-day laid stress on difficulties in the present position in connection with poultry development in India. But I see everywhere signs of increased interest, and increased interest means more possibility of advance. The Indian Poultry

Club was the pioneer, with some similar bodies in South India, in fostering this interest. The United Provinces Poultry Association has done excellent work in North India. We are just making a move forward in the West of the country by the formation of the Bombay Presidency Poultry Association. I feel that the psychological moment has arisen for a big advance, and I hope that the first All-India Poultry Conference may be the means of crystallizing the great enthusiasm now existing, and setting us all—Governments, business men, and private workers—to work on lines which will make India not only the original home of poultry in general, but also the centre of the most advanced poultry development in the world.

A REMEDY FOR A DIE-BACK DISEASE OF ORANGE TREES.

BY

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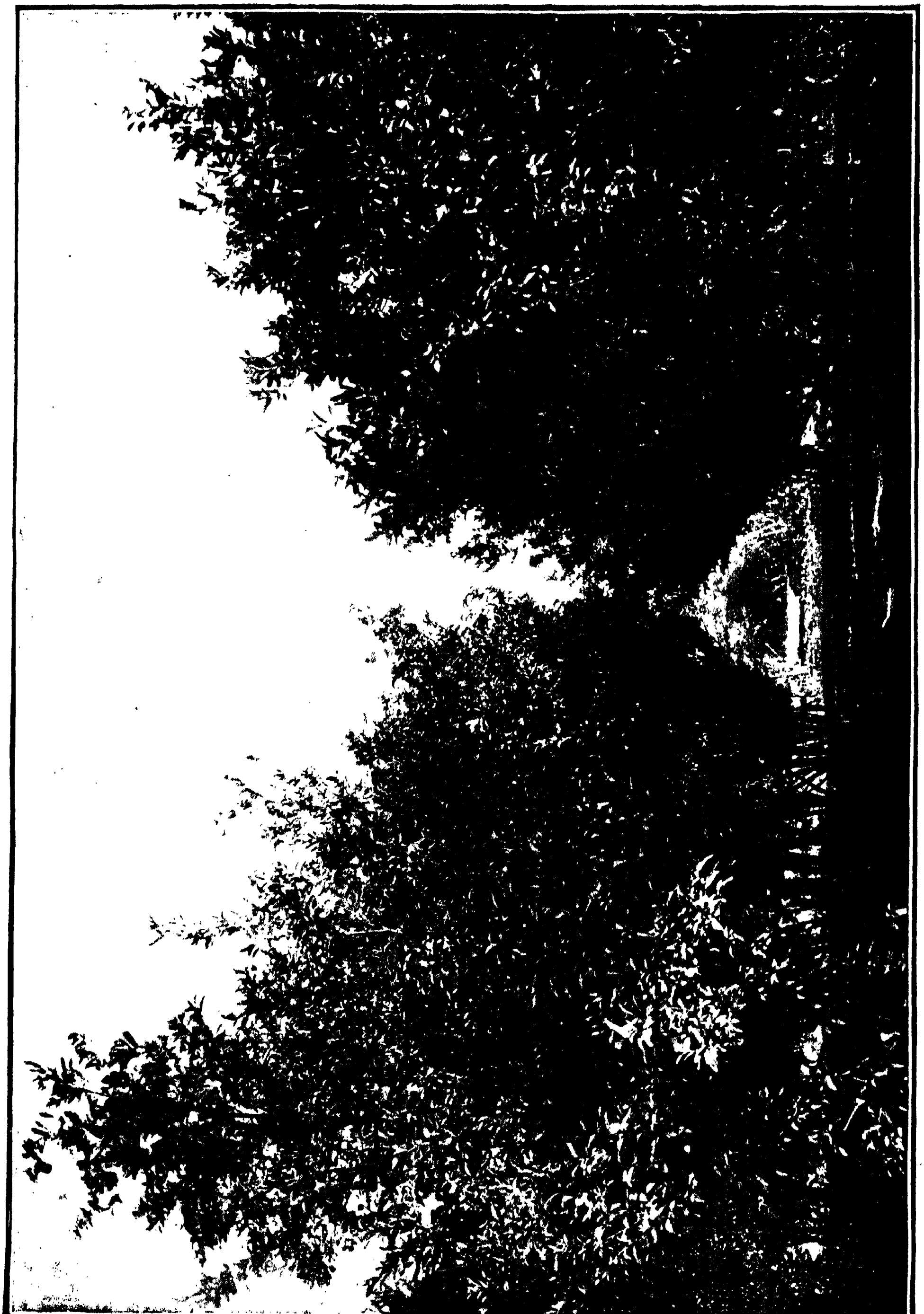
IT has been observed in many places that the orange plants and others belonging to the same family suffer from what is called the die-back disease. In this disease branches of the plants begin to dry up and die from the end backwards, and the whole plant then gets affected and dies in four to eight years after the attack begins. The plants do not generally suffer from this trouble in the young condition but get the attack after they begin to bear and after their roots go deeper into the soil. The die-back trouble exists especially in clayey and sticky soils. It may be found in places where the roots do not get enough aeration on account of other causes. The examination of the plants and the affected branches has not so far enabled us to trace the trouble to any insect or fungus disease although it may be a secondary effect of a disease.

There are several cases of the die-back trouble in the Bombay Presidency. Recently some cultivators from Ahmednagar District referred the matter to the Agricultural Chemist to the Government of Bombay and asked for his advice. A visit to the gardens where the orange plants were suffering showed clearly that the trouble was due to the sticky nature of the soil which prevented proper aeration, because the plants on clayey soils only suffered, while in the same locality where the plants were on loamy soils there was not even a single plant suffering from the die-back. In order to give proper aeration to the roots of the plants in the sticky soils the cultivators were advised to open trenches in the plantation and fill them up with bricks, stones and branches of plants and then cover them with ordinary soil. Cultivators generally do not take up such suggestions unless they have an ocular demonstration of the good effects of the remedy proposed. It was, therefore, decided to make a definite experiment in this connection. The Sub-Divisional Officer in charge of the Irrigation Bungalow at Deolali in Ahmednagar District agreed to try the experiment in the garden of the Irrigation Bungalow, as his orange plants also were suffering from the die-back disease.

The orange plantation in this garden was started in 1911-12 and the plants began to bear fruit in 1918-19. The die-back disease appeared first in 1921-22 and by 1924-25 it had increased so much that it was feared that the plants would die in about four years more. The plantation is on a clayey soil. The plants in this garden are in four groups with foot paths between. They are placed 12 ft. 6 in. from each other both ways.

ORANGE PLANTS SUFFERING FROM DIE-BACK.

PLATE XII.



ORANGE PLANTS RECOVERED FROM DIE-BACK.

It was decided to dig trenches in the worst portion, leaving the other parts without trenches for comparison. Dry branches from all the plants with trenches and without trenches were removed in May 1925. Trenches were dug in the same month between the rows of plants so that the plants had generally trenches on two sides. Some plants, however, had trenches only on one side and some others with trenches on three sides also. The trenches were dug three feet wide and three feet deep (up to murum in this case). The lowest nine inches were filled with broken tiles and stones, and the remaining part was filled with the original soil mixed with manure. This manure was not in excess of what the non-treated plants got. The only difference was that the plants with trenches had the manure in the trenches, while the other plants got the manure in a ring round each plant as usual. The manure consisted of five baskets (20 lb.) of farmyard manure, 10 lb. of bonemeal and 3 lb. of oil-cake per plant. Excepting the trenching all the plants received the same treatment throughout.

In order to see the effect of the trenches on the die-back disease and the plants in general, observations were taken on 24th and 25th of March, 1926, *i.e.*, ten months after the trenches were dug. The appearance of the plants with trenches showed a distinct improvement with regard to foliage and bearing of fruit, while the plants without trenches showed that they were going from bad to worse and had but very little bearing. The difference is clearly shown in Plates XI and XII. The fruit and the leaves being both of green colour are not seen easily; the difference in the foliage is quite clear. There are several dry branches on the affected plants, while there is practically no dry branch on the recovered plants. A detailed plant to plant observation of the plots with and without trenches was made to make the enquiry complete and to bring out the results in definite figures.

In the description which is given below the die-back condition of the plant is described as worst, worse, bad, slight and no die-back, while the bearing condition is described as no bearing, slight, fair, fairly good and good.

There were nine plants with trenches on three sides. Out of these, seven plants showed no die-back, while only two showed a slight attack. Seven plants had good bearing and two fairly good bearing.

There were 53 plants with trenches on two sides. These form the largest number amongst the treated The die-back condition of these on the days of observation was as follows:—31 plants out of 53 did not show any die-back, 22 plants showed a slight attack and only one was bad. With regard to the bearing of fruit, 32 showed good bearing, 17 fairly good bearing and 4 fair bearing but there was no plant which had no bearing.

Fourteen plants in the treated group had a trench only on one side. Out of these, only one showed to be very bad with die-back, two bad, six with only a slight attack and five without any attack. In their bearing capacity four were good, seven fairly good and three were fair.

The group of plants without trenches consisted of 74 plants. These were kept exactly under the same conditions as those with trenches. With regard to die-back condition, fourteen out of these could be put down as the worst, 25 as worse, 30 as bad and 4 with slight attack and only one without the die-back. In their bearing capacity as many as 40 had no fruit bearing, 15 slight, 12 fair, 5 fairly good and only two showed good bearing.

These results given above have been calculated on percentage basis so as to bring out clearly the difference in the two groups of plants. Table I gives the die-back condition of the plants as expressed per 100 plants, while Table II gives the bearing capacity of plants expressed per 100 plants.

TABLE I.

Die-back condition per 100 plants.

	Worst	Worse	Bad	Slight	None
	%	%	%	%	%
With trenches on three sides	..	..	..	22·3	77·7
With trenches on two sides	..	.	..	41·5	58·5
With trench on one side .	.	7·1	14·3	42·8	35·7
Without a trench . .	20·1	33·8	40·5	5·3	1·3

TABLE II.

Bearing condition per 100 plants.

	No bearing	Slight	Fair	Fairly good	Good
	%	%	%	%	%
With trenches on three sides .	..	..	..	22·3	77·7
With trenches on two sides . .	..	..	7·5	32·1	60·4
With trench on one side .	..	..	20·5	50·0	28·5
Without a trench . . .	54·0	20·3	16·2	6·8	2·7

The tables speak for themselves. When the experiment was started it was not expected that the improvement would be so much and so quick. Generally, it is easy to prevent an attack, but it is very difficult to cure it once it comes in.

In this case more aeration seems to be the only remedy, because the improvement is proportional to the amount of aeration since the best results are obtained with trenches on three sides.

The question of expenses is sure to crop up in connection with this remedy as in other remedies. On enquiry it was found that at Deolali the charges for digging and filling trenches of the type described above would be annas 12 per cubic foot and would be about Rs. 200 per acre. The material required to fill in the trenches may be stones, dry leaves and branches (these are available in gardens) for the lower 18 inches, and the upper 18 inches may be filled with the original soil. The materials may cost about Rs. 100 per acre. Roughly speaking, each plant would cost about Rs. 1-8 extra. The digging and filling in of trenches may be done bit by bit at the convenience of the cultivator to reduce the cost. The trenches may be left open if that is possible. The remedy in the particular conditions given above seems to be quite effective and is worth while being tried wherever the orange plants are suffering from the die-back trouble.

SELECTED ARTICLES

THE SUGAR INDUSTRY OF THE INDO-GANGETIC PLAIN.*

THE Indo-Gangetic plain for the purposes of this note refers mainly to the United Provinces of Agra and Oudh, and to that portion of Bihar and Orissa which lies north of the Ganges. The whole area under consideration lies roughly between the parallels 24° and 28° N. and 82° and 87° E. It is, therefore, wholly extra-tropical, and in this respect compares with Louisiana, Argentina, Egypt, and Natal.

The magnitude of the industry in India is frequently overlooked ; in all in India little short of 3,000,000 acres of sugarcane are annually planted, of which 1,500,000 or thereabouts are contained in the United Provinces and 300,000 in Bihar and Orissa. Of the balance, 400,000 acres will be found in the Punjab, 200,000 in Bengal, 100,000 in Bombay. The other divisions of the Indian Empire contribute much smaller areas.

Historically this area is of great interest, forming, in common with two other great river systems the Nile and the Euphrates-Tigris, the localities whence have originated much of our present religious and philosophical ideas.

It was in this Indo-Gangetic plain that Sakya Muni or Gautama, usually referred to by Europeans as Buddha, was born about 550 B. C., at Kapilavastu not far from Uska Bazar. At Gaya he received his revelation, and perhaps died at Kasi, about 30 miles from Gorakhpore. It was in this area, too, that the great Maurya dynasty ruled, with their capital at Pataliputra (Patna) from 321 to 200 B. C., and whence Asoka promulgated those remarkable moral edicts graven on rocks and pillars of stone, many of which stand erect to-day. Three such pillars remain to-day in Bihar, all close to the east bank of the Gandak. They are by some scholars believed to mark the spots where Gautama rested and taught on his last journey. If this supposition is well founded, he must have passed close to the sites at present occupied by the mills of the Champaran, Pursa and United Provinces Sugar Companies (9, 10 and 11 on the accompanying map).

It was in this area also that Gautama's great contemporary, Mahavira, organizer, if not the founder, of the Jain religion, was born at the city of Vaisali, the site of which has been placed at Saraya, some 18 miles from Muzafferpore ; and it was here, too, that at least one General Council of the Buddhist Church was held.

As indicating the great antiquity of sugarcane culture in this area it is only to be remembered that the Sakya clan had adopted the sugarcane as their badge, and

* Reprinted from *Int. Sugar Jour.*, XXVII, No. 322.

indeed the opening verses of the Chinese canon of the Buddhist scriptures run :— "There was a descendant of the Ikshvaku (*i.e.*, sugarcane) family, an invincible Sakya monarch" referring to Suddhodana, the father of Sakya Muni. And again in the Institutes of Manu, VIII, 341, perhaps composed at a yet earlier period, there appears the passage, "A twice born man who is travelling and whose provisions are exhausted shall not be fined if he takes two stalks of sugarcane and two roots from the field of another man." Probably then it would be no exaggeration to attribute to this area an un-interrupted period of sugarcane cultivation of not less than 3,000 years.

At a later date Bihar must have obtained some fame as a progressive sugar producing area, since records exist that about 600 A. D., the Chinese Emperor Tsai Heng sent agents to Bihar to learn the art of manufacture of sugar, thus perhaps forming the first instance on record of a technical commission investigating manufacturing processes in a foreign country.

From these early times down to the present day sugarcane has always formed one of the staple crops of this area, although it is only in comparatively recent times that European capital has been invested. The Honourable East India Company showed an interest in developing trade in sugar in the latter part of the 18th century and an exhaustive report was issued in 1792. There does not appear to have been any outcome of the report, and it was not till about 1840 that any attempt was made to establish an industry. At this time there appeared in Bihar a Mauritian Planter, Robinson by name, and presumably the author of a work "The Bengal Sugar Planter." A number of factories were started but none ended in success. A lampoon of the time thus describes the failure—

"The Sugar King stretched out his hand,
Talked of the cheapness of labour and richness of the land,
Of twenty maunds a begah.
Take cypher from the nought, divide the ten by two,
The result will be the product exceeded but by few.
Then things went on right jolly
Till the district was dotted over with monuments of folly."

Another brochure of the time describes a planter travelling by boat up the Gandak, his cargo consisting of two boilers in one of which the planter lived, the other being occupied by a bear. It is recorded that the bear arrived safely but that the boilers did not.

Judging, however, from "The Bengal Sugar Planter," Robinson was a man of parts and his ideas of sugar manufacture were well abreast of the times. The factories he advocated and described in his treatise would be considered for that period thoroughly well equipped. It is interesting to note that vacuum pans were constructed by Jessop & Co. in Calcutta previous to 1849.

A new start was made very early in the present century, and was directly stimulated by the decline in indigo prices when a factory was established at Ottur by the India Development Co. This enterprise did not meet with success, but it was shortly followed by others at Japaha, Pursa, Marhowrah, Barrah and Purtabpore all of which remain and operate to-day as successful concerns. At first, these factories were of very modest size, being designed for 200 tons of cane per day and were equipped with only 8-roller mills, and although the size has not much increased it will be seen from the annexed tabulation that the equipment has been materially improved.

Extent of the industry.

In all there exist in Bihar and the United Provinces 18 central factories, the positions of 16 of which are shown in the accompanying map. The two not shown, Rosa and that of L. H. Brothers, are about 120 miles north-east of the Gandak and close to Bareilly. Details of the equipment and capacity of these factories are given in a tabulated form below. Compared with the factories of Cuba, Java, and Hawaii, their capacities are very modest, and although the equipment still leaves much to be desired in many cases, certain factories are well provided with machinery.

Allowing 120 working days to a campaign, the united capacity of all the factories scheduled would amount to about 750,000 short tons of cane ; so great a quantity of cane has never yet been milled in one year and 350,000 tons or thereabouts is the most which has yet been achieved.

Source of cane.

The total tonnage of cane in the area under discussion will in a year of favourable monsoon amount to 20,000,000 tons, and of this by far the greater portion is grown by ryots or peasant proprietors in small holdings. These proprietors are quite independent of the factories and have full liberty to sell their cane or manufacture it into *gur*, and actually not as much as 3 per cent. of the total quantity grown finds its way to the central factories.

Apart, however, from the ryot, there are mainly congregated in the districts of Champaran and Darbhanga some thirty-odd European-owned concerns which provide the major portion of the raw material to the Samastipore and Champaran centrals. Two other of the centrals, Japaha and Purtabpore, combine cultivation on the large scale with manufacture, and savour somewhat of the typical old time West Indian plantation. The part played by the European planter in cane production is, however, small compared with that due to the indigenous tiller of the soil, and those that remain may be regarded as the rearguard of the once numerous and wealthy army of Bihar planters.

TRANSPORT.

Reference to the map on p. 122 will show that nearly all the centrals are located on one or other of the lines of the Bengal and North-Western Railway ; the development of the modern sugar industry could not have materialized in the absence of a railway system. The transport of cane to the factories is, however, dependent on bullock cart haulage as feeders to the railway, and in addition much cane is carried directly to the mills by bullock cart. The limit of this slow but certain method of transport is about 10 miles, whether as feeder to the railway or direct to the factory.

Although no statistics are available, it may be estimated that 45 per cent. of the cane which reaches the centrals arrives directly in carts and 55 per cent. is transported by rail after being delivered to loading stations by cart. During the cold weather but little difference is noticeable as between cart and railway cane, but as the temperature rises deterioration in transit of railway cane is readily to be detected, especially when the length of haul reaches 50 miles and more.

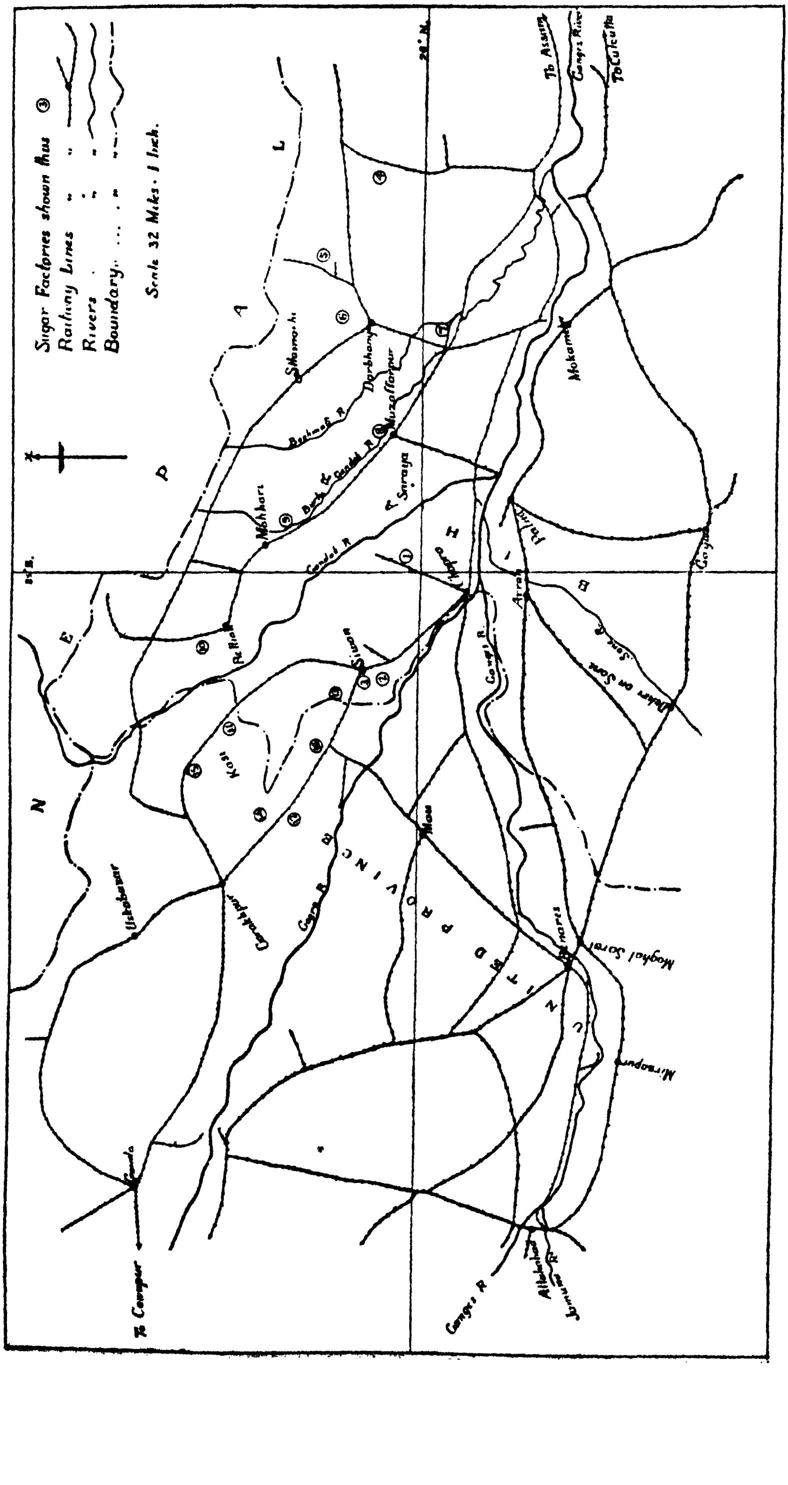
The Bengal and North-Western Railway is a metre gauge system and the average cane load of a wagon is 16,000 lb. The wagons supplied are of such construction that unloading is necessarily performed manually.

The Bengal and North-Western Railway is not connected directly with the East Indian Railway which runs south of the Ganges. All material from European ports landed at Calcutta has to be transhipped at Mokameh Ghat and ferried across the Ganges, as also has the limestone used in carbonation factories, the source of this being quarries at Dehri-on-Sone. This break of gauge leads to vexatious delays and losses in the transport of machinery and supplies.

VARIETIES OF CANE GROWN.

What is known of the varieties of cane grown in Northern India is mainly due to C. A. Barber who has unfortunately retired before his studies were complete. He has separated the canes of Northern India into five classes, Mungo, Saretha, Sunnabile, Pansahi and Nagori. His studies deal mainly with the Saretha and Sunnabile classes as they are found in the Punjab, where they apparently form the predominant types. In Bihar, north of the Ganges, and as far west as Gorakhpore, the dominant canes grown belong to the Mungo group.

Three types occur, distinguished by the names Hemja, Bhurli and Rheora. These varieties are very close to each other, and the names become interchanged from district to district, what is called Bhurli in one village being named Hemja in another, and the three varieties are certainly much intermixed in the ryotti cultivation. They are described by Barber as of a dwarf bushy habit, but under superior conditions the dwarfness tends to disappear, though the bushy habit is always very pronounced in young cultivation. These canes are of medium diameter and of pale green colour, becoming yellow tinged with pink where sun exposed.


Sugar Factories shown thus
Railway Lines
Rivers
Boundary
Scale 32 Miles = 1 Inch.
N E P A L
B I H A R
U N I T E D P R O V I N C E S
Sitamarhi
Darbhanga
Muzaffarpur
Motihari
Siwan
Chapra
Arrah
Patna
Mokameh
Gaya
Son R.
Dehri on Sone
Moghal Sarai
Benares
Mirzapur
Allahabad
Jumna R.
Ganges R.
Gogra R.
Gandak R.
Gorakhpur
Uskabazar
Mau
Gonda
To Cawnpore
To Assam
To Calcutta
Ganges River

Factories	Reference in map	Capacity short tons cane per hour	Number of rollers	Evaporators	Process	Suppliers
Cawnpore Sugar Works, Marhowrah.	1	20	14	Triple	Carbonation	Harvey Engineering Co.
Bihar Sugar Works, Pachrukhi	2	20	11	Quadruple	Ditto	Maschinenfabrik Grevenbroich.
New Savan Sugar Factory, Savan.	3	15	12	Triple	Sulphitation	....
Bihar Sugar Co., Sepaul	4	10	8	Do.	Ditto	....
Darbhanga Sugar Co., Lohat	5	25	8	Do.	Ditto	Mirrlees Watson Co.
Ryam Sugar Co., Ryam	6	20	11	Do.	Carbonation	Ditto.
Samastipore Central Sugar Co., Samastipore:	7	20	14	Do.	Sulphitation	Mirrlees Watson and Blair, Campbell and McLean, Ltd.
Japaha Sugar Factory, Japaha	8	15	8	Do.	Ditto	Harvey Engineering Co.
Champaran Sugar Co., Chakia	9	25	17	Do.	Carbonation	Ditto.
Pursa Sugar Factory, Pursa	10	15	11	Do.	Sulphitation	Ditto.
United Provinces Sugar Co., Tumkohi.	11	20	11	Do.	Ditto	Ditto.
Cawnpore Sugar Works, Gauri Bazar.	12	10	14	Do.	Ditto	Mirrlees Watson Co.
Purtabpore Sugar Factory, Purtabpore.	13	20	11	Do.	Carbonation	Harvey Engineering Co.
Saraya Sugar Factory, Chauri Chaura.	14	10	8	Do.	Sulphitation	....
Padrauna Raj Krishna Sugar Works, Ltd., Padrauna.	15	15	8	Do.	Ditto	Harvey Engineering Co.
Bhatni Sugar Factory, Bhatni	16	25	11	Do.	Ditto	Ditto.
L. H. Brothers Sugar Factory, Pilibhit.	..	?	?	..	....	....
Rosa Sugar Factory, Shahjehanpore.	..	?	?	..	....	....

In the north-east of Bihar and especially in the vicinity of Sitamarhi, adjacent to the Nepal Frontier, large areas are laid down in canes belonging to the Nagori group. The canes are of narrow diameter, very fibrous and with swollen nodes. They have the characteristic of thriving in swampy land, and may often be seen growing in the same field as rice. They ripen, or at least afford a juice of high sugar content, as early as October, when it is customary for the ryots to begin their harvest. This early harvest is connected with the Chhat festival which demands in its ceremonies freshly made *gur*. The varieties distinguished are Nagori, Sewari, Kewali, Hathooni, Haruki and Baruk, the latter name merely meaning swamp cane.

Barber's Pansahi group is represented fairly extensively by the Chinia cane which is also grown in low-lying land and is very close to the Uba cane which has lately been so prominent.

From time to time introductions of the traditional varieties have been made, but no one has ever succeeded in becoming established on an extensive scale. A thick red cane known as Australian or Maxwell after its introducer is grown to some extent by a few European planters.

South of the Ganges different types of canes more nearly approaching the noble canes are cultivated. One variety in particular, Puri, in fairly extensive cultivation has nothing to differentiate it from a noble cane in the laymen's eyes.

Recently following on the cane breeding work of Barber and Venkatraman, and on the efforts of the Sugar Bureau under the direction of Wynne Sayer, various hybrid seedlings have been introduced and have become extensively planted with a great measure of success. These are :—

Coimbatore 210, a seedling from P. O. J. 213, the probable male parent being either M. 2 or M. 1017, two Madras seedlings.

Co. 213, a seedling from P. O. J. 213, the probable male parent being Kansar or possibly M. 2. Kansar is a cane belonging to Barber's Saretha group.

Co. 214, a seedling of Striped Mauritius, the male parent being probably a cross between Saretha and *S. spontaneum*.

As the parentage of P. O. J. 213 is Chunnee × Black Cheribon, these canes have a very interesting ancestry.

Composition of the Cane.

Systematic routine observations over a group of six factories afford the following data, which refer mainly to the Hemja variety and its congeners :—

	Sugar per cent.	Fibre per cent.	Purity first mill juice
1922-23	12·20	14·38	82·67
1923-24	11·63	13·81	78·94
1924-25	11·63	14·63	79·83
Max. of one factory	13·00	11·80	83·99
Min. of one factory	10·18	15·14	74·17

These data refer to the material as received at the carrier and to the composition as worked backwards from the factory records, and not as obtained from direct analysis of the stalks. The behaviour of the cane during the harvest is precisely the same as observed elsewhere in similar latitudes, *i.e.*, from December onwards the sugar content and purity increase reaching a maximum in March and April after which time a slow decrease is observed. At the period of maximum sugar content the cane may occasionally contain as much as 15 per cent. sugar with a purity in first mill juice of 88.

Factory yields.

With an average sugar content of 11·6 in cane and a properly equipped and efficiently operated factory, a yield of 9·5 per cent. in white sugar should be obtained. A yield of over 9 per·cent. has, however, been obtained by only two factories in India, and the return consequent on inefficient manufacture and defective operation is much less.

For the year 1924-25 a certain group of factories reputed to be the least inefficient in India obtained a yield of 8·69 per cent. with a maximum yield in one factory of 9·70 per cent. The average yield in all other factories outside this group was about 6·5 per cent. with a maximum of 8·0 per cent.

Climate.

The area under review presents characteristics of climate found in few other cane producing areas. It is remarkable for intense heat in summer reaching up to 100° F. in the shade, and for a cool winter, when the temperature exceptionally falls to 32° F. The monsoon is usually expected to break about the middle of June and continue to the end of October. During this period as much as 65 inches of rain or as little as 15 inches may fall, the average being about 45 inches. Isolated rainfalls also occur not infrequently in the cold weather from December to February, and the submontane areas may be visited by heavy local showers at any time.

Cane growing under these conditions is somewhat hazardous and the promise of an excellent crop may be falsified by a late monsoon, and on the other hand, an established crop may be severely damaged by excessive late rains resulting to floods. These floods often are not consequent on precipitation in the cane-growing areas but follow on falls in the submontane districts.

A peculiarity of this area is the hot west winds which commonly blow from mid-March onwards till the break of the monsoon towards the end of June. These winds having passed over the arid desert regions of the north-west are of low humidity and cause drying up and wilting of standing cane. During the period that they blow, their effect in causing deterioration of cane in transit can easily be seen in factory records.

Soils.

The soils of this area under consideration have not been so extensively surveyed as have those of other great sugar producing areas. From casual inspection they would be classed as sandy loams, and differences can be observed dependent on whether the soil has been influenced by the deposit from the Ganges, the Gandak, the Gogra or other of the rivers flowing south-east from the Himalayas. Soil types influenced by smaller rivers such as the Bagmati are often well defined, as some of these, when in flood, appear to bring down a deposit distinct from that afforded by the larger rivers.

The most detailed account of Bihar soils is that due to Davis mainly in connection with indigo research, and his analyses indicate that the soils are amply supplied with lime, have a good supply of potash, but are deficient in nitrogen and phosphate. Typical analyses of a Bihar soil would be, following Davis' analyses :—

	Total per cent.	Available per cent. (Dyer's method)
Lime	10—25	....
Potash	0·3—0·8	0·004—0·1
Phosphoric acid	0·04—0·1	Trace —0·005
Nitrogen	0·02—0·1	....

Going westward towards the United Provinces the percentage of lime falls and the available phosphoric acid increases.

Diseases.

A full account of the diseases of the sugarcane mainly as they affect the Indo-Gangetic plain is to be found in Dr. Butler's "Fungi and Disease in Plants." The most widespread disease which the layman can readily recognize is the red rot (*Colletotrichum falcatum*).

The present writer has had extensive opportunities of examining cane delivered to central factories, and it seems to him that red rot is far more prevalent in the western portions of the Indo-Gangetic plain than in the eastern. Some extensive areas seem nearly free and the correlation between sugar content of the cane and absence or presence of red rot is remarkable. Every year, however, much material damage occurs from this fungus, and in certain areas it would appear that the whole crop and soil is infected so that healthy cuttings for seed are unobtainable.

There are also indications to be found in examining canes selected from the carrier that wilt (*Cephalosporiun sacchari*) and collar rot (*Hendersonina sacchari*) are also present, judging merely from the microscopic appearance of the interior of the

affected cane. In such cases an intensely red coloured juice is obtained, the red coloration with the sulphitation process persisting in the crystals of sugar.

Of the leaf spots, the brown leaf spot (*Cercospora sacchari*) is easily recognized and it appears to be more prevalent during prolonged spells of wet weather. Fields may often be observed where the leaf surface immobilized by this fungus forms a notable percentage of the whole.

Apart from these diseases, mosaic is widely spread all over Northern India. The writer suspected this condition from his first sight of cane fields but avoided expressing an opinion until he had had the expert opinion of cane specialists to whom he sent suspicious specimens. The unrecognized overhead loss in Northern India due to mosaic is probably very great, and being unrecognized and accepted it has not up to the present been accorded concerted prophylactic action.* The variety mainly grown, Hemja, should possibly be classed as tolerant to this disease. Notwithstanding, the endemic presence of mosaic would appear to the writer as a major contributory cause to the habitual low yields obtained in the Indo-Gangetic plain.

Insect pests.

The insect pests of Northern India have been described in detail by Maxwell Lefroy. Most noticeable of all are various moth borers. Top, stem, and basal borers are noticed and collectively much damage is done. The most frequent of these is the white top borer, *Scirpophaga auriflua*, and following on this the root or base borer, *Polyocha saccharella*. As elsewhere, while considerable areas in one location may be damaged, other adjacent areas may escape. Other common pests recognizable by the amateur include a plant louse, a leaf sucking hemipteron, and a small beetle which attacks the very young cane shortly after germination. Apart from the moth borers the most serious pest is probably the white ant, which, especially before the monsoon breaks, will destroy a large number of cuttings.

Cultivation.

Generally in Bihar and the United Provinces cane is not grown on the same land more than once in four years, and it is only exceptionally that a ratoon crop is taken. The land in the interval may be occupied by pigeon-pea, tobacco, chillies, and various grains and leguminous crops. Preparation of the land is performed with a wooden plough tipped with iron and drawn by a pair of bullocks. After numerous ploughings the land is rolled and levelled and generally a superfine tilth is obtained. The cane is planted on the level and not in trenches. Very close planting is common and about 10,000 three-node cuttings will be used to an acre. After planting but little further work is done by the ryot.

* This extensive occurrence of mosaic in North India is news to us (Ed. *Int. Sugar Jour.*)

On the European-owned concerns, tractor ploughs and implemental cultivation are common, and the operations here have more in common with Western methods. Indigo still is grown in rotation with cane on certain of these plantations, and green-manuring with sann-hemp (*Crotalaria juncea*) is a common practice. It is a matter of regret that the indigo industry is moribund, as this being a legume provided a valuable rotation crop for cane.

IRRIGATION.

In Bihar, that is to say the eastern portion of the area under review, irrigation of the cane is very little practised by the ryot. In the more westernly portion, *i.e.*, in the United Provinces of Agra and Oudh, cane is regularly irrigated, the water being manually lifted from shallow wells by the Jungla or Paicota. This consists of a beam pivoted on a pole, to one end of the beam being attached a bucket, the operator pulling at the opposite end of the pole. Such a means may irrigate laboriously half an acre of cane. On the European-owned concerns irrigation is occasionally practised but only as a means of saving the cane crop consequent on a late monsoon. The idea of irrigation is entirely protective, and intensive irrigation independent of and in conjunction with the monsoon for the production of the maximum tonnage from a given area does not seem to obtain. One concern, however, has lately put down a scheme on the intensive idea, but with what economic result is not yet known.

YIELD PER ACRE.

For the season 1922-23, the official departmental statistics give :—

	Acres	Tons *gur*	Cane per acre, tons	*Gur* per acre, tons	*Gur* per cent. cane
Bihar	3,073,000	3,186,750	10·3	1·03	10
U. P.	1,543,902	1,629,000	..	1·06	..

These yields are probably the smallest in the world, and with so poor an agricultural yield it is a matter of surprise that an industry of such magnitude can exist. These yields reflect the inadequacy of the cultivation methods pursued by the peasant proprietor, for yields much in advance of these are regularly obtained on the best managed of the European-operated concerns. With the newly introduced canes of the Co. series, yields of 35 tons per acre have been obtained on an extensive scale, and with systematic irrigation combined with proper manuring and cultivation, there does not seem any reason why an average of 25 tons should not be realized.

THE GUR INDUSTRY APART FROM THE SUGAR INDUSTRY.

It will be readily seen that the sugar industry forms a very small proportion of the whole cane-growing industry, and of the total of 18,000,000 tons of cane produced in the Indo-Gangetic valley not more than $2\frac{1}{2}$—3 per cent. on an average is handled in modern factories. This phase of the industry may perhaps be discussed in a further communication.

GETTING THE BEST OUT OF PASTURES.*

BY

J. G. STEWART,

Ministry of Agriculture, England.

It has long been recognized by the practical man that live stock, whether horses, cattle, sheep, or pigs, cease to grow and thrive, as they should do, when continuously herded in large numbers on the same grazing grounds. This absence of progress is usually more marked in the case of old, mature, unimproved pastures than in that of newly-established or improved grazings.

Land that is continuously stocked, more particularly if overstocked, tends to become infested with parasites which gradually undermine the health of the animals, and, in many cases, cause wasting and death. The Americans have perpetrated the phrase " permanent pastures perpetuate parasites." Its truth is its justification.

In the cure of disease, however, science has made less progress than its prevention, and it is to the latter aspect that I propose to invite the attention of farmers. At the present time, when so many farmers are disposed to sow their arable down to grass there is need for reflection as to whether this process may not, in the interests of their stock, be carried too far. Scottish farmers solved their economic difficulties in the past by converting the normal four-course rotation with its 50 per cent. of corn and 25 per cent. of roots into a six or seven-course rotation, with two or three instead of one year's grass. With a rotation containing three years' grass it is still possible to allot 43 per cent. of the land to corn, and, at less expense, to produce as much corn as on the former 50 per cent. So with roots, reduced from 25 per cent. to little more than 14 per cent., it is possible, by being able to concentrate on a smaller area, to produce, if not quite as much in the aggregate as formerly, at least sufficient, in the light of modern experiments, to satisfy all requirements of animals in winter.

Temporary leys.

The objection is often raised that it is only in a comparatively wet and cool climate, such as prevails in Scotland, that one can hope to establish satisfactory temporary leys. While the establishment of good pastures may be difficult in very driest parts of England, there is abundant evidence to show that the practice is capable of much wider adoption than is generally supposed. The main considerations in establishing a good sward, anywhere, are (1) soil fertility, particularly as regards humus, phosphates, and, where it is deficient, lime ; (2) a slight covering of fine

* Reprinted from the *Farmer and Stockbreeder and Argi. Gazette*, No. 1889.

soil for the seed over a firm sub-surface; (3) the inclusion of wild white clover in the seed mixture; and (4) judicious mowing and grazing afterwards.

In regard to (2), the best implement for sowing seeds on hard ground is the ordinary corn disc drill, half of the seed being drilled preferably in one direction and half across. As for (4), it is usually best to take an early hay crop the first year. In the second year, on hard ground in a dry district, where the nurse crop was winter corn, a complete covering of luxuriant mixed herbage has been obtained by light grazing and self-sowing. Temporary leys, if properly nursed, are suitable either for hay or grazing. Where a mixed stock is carried, such as cattle and sheep, the question whether the young grass should be grazed or mown is of some importance. Old grass that has become "stale" from continuous stocking should be "rested" and freshened by being laid up for hay; in extreme cases, it may be advisable to break up and relay. On the other hand, if it is perfectly sound and healthy, it may continue to be used as pasture, and the young grass, which in many districts will grow a bulkier and better quality crop, may be mown.

Essence of stock farming.

Frequent rests and changes of ground are of the essence of successful stock farming, and for this small fields are necessary. Big, open fields for corn; small, sheltered fields for grazing should be the aim of all progressive stockmen. The arable farmer, turned grazier, will find that successful grass-farming is a much more intricate business than it seems; indeed, the most experienced grass farmers are only beginning to realize the infinite possibilities of scientific management applied to grass land. The limit of development has not been reached with the application of basic slag and the inclusion of wild white clover in the seed mixture.

It was pointed out years ago by Sir Daniel Hall that for the establishment of a successful sward a nitrogenous manure was, under certain circumstances, indispensable. The Germans appear to have reached a further stage in the productiveness of pastures by the use of nitrogenous manures along with the phosphates, followed by intensive, short-period grazing and frequent mowings. Experiments on similar lines have now been started in this country.

For the proper control and development of pastures Professor Stapledon advocates a judicious and a more general use of the mowing machine. Most farmers, if they mow their pastures at all, defer the operation till after the hay harvest. This is often too late. Where pastures have rushed up beyond the control of the stock they can be mown to best advantage before the normal hay harvest commences.

These are only a few of the directions in which developments are possible. Still another, with perhaps even more far-reaching effects, is that now being investigated by Dr. Orr and his colleagues at the Rowett Research Institute.

He has shown conclusively that the mineral content of the diet has a profound influence on the health, rate of growth, and productive capacity of farm animals, and he suggests that chemical analyses of the herbage would show that the pastures

which experience has proved to be of most value for feeding would also prove to contain the essential mineral elements in the amounts and proportions nearest to those required by the animals feeding on them.

ANIMALS' NATURAL CHOICE.

Natural or unimproved pasture, that is to say, pasture which has not been treated with mineral manures, has a varying mineral content in different localities. Animals ranging over wide areas appear to be guided by their appetite to vary their feeding ground, so that the chances are that in the whole of their grazing there would be no constant deficiency or excess. In fact, there is evidence to show that sheep, in grazing, choose those portions of the pasture whose mineral content most closely approximates to that of good, cultivated pastures. Dr. Orr has further shown that good mixed pasture contains the varying elements in proportions somewhat similar to those which are found in milk, and might, therefore, be presumed to be suitable for growth and the maintenance of health, as indeed is found to be the case in practice.

The value of free range for grazing sheep is generally recognized by practical farmers, even if the reasons have not hitherto been fully appreciated.

Dr. Orr points out that disturbances in nutrition due to deficiency of minerals in natural pastures would be liable to occur—

(*a*) When animals accustomed to wide ranging are restricted to a limited area.

(*b*) When animals reared on cultivated pasture, and characterized by a rapid rate of growth, are transferred to a natural pasture which contains markedly less of one or more mineral elements than the pasture on which the type has been evolved.

(*c*) When over a long period pasture has been depleted in those mineral elements which are used as constructive materials in growth, as when animals reared on the pasture are sold off without any measures being taken to restore to the soil minerals equivalent to those carried off in the bodies of the animals.

SHEEP IN THE FALKLANDS.

Instances are cited in which, under these conditions, malnutrition in grazing animals has actually occurred, the most interesting perhaps of which is that relating to the experience of sheep breeders in the Falkland Islands. Sheep have been reared extensively on these islands for about forty years, and neither foodstuff nor manure has been imported. During the last twenty years it has been increasingly difficult to rear lambs, and from the result of Dr. Orr's investigation it seems evident that the difficulty is mainly attributable to malnutrition, the primary cause of which seems to be deficiency of calcium in the soil and in the herbage.

It has been shown by many well-known investigators in this country that the application of mineral fertilizers can greatly improve poor pasture as judged by its feeding value and the change in the character of the herbage; but little has been done to ascertain whether there is any correlation between the amount and composition of the mineral matter of pastures and their nutritive value.

It is common knowledge that pastures in some districts produce animals with plenty of bone, large frames, and vigorous constitutions, and in other districts animals which, compared with the former, are stunted in growth.

Mineral content and disease.

It is also common knowledge that there are fairly well-defined areas of "sound" and "unsound" land, areas on which sheep will remain healthy only for a limited period, after which certain diseases develop, diseases which do not appear if the sheep are periodically grazed for a time on a different area. Many diseases are due, of course, to parasites; but there is little doubt that the nature of the pasture is an important factor both in rate of growth and in susceptibility to certain diseases, and Dr. Orr considers it reasonable to adopt as a working hypothesis the view that the mineral content of the pasture may have an influence in this direction.

It has been further suggested by Captain Walter E. Elliot, M. P., that deficiency of mineral elements in hill pasture might be a cause of the malnutrition and mortality of sheep which are not uncommon on some of the sheep runs of the Border country. Investigation is still proceeding, but a superficial survey seems to indicate definitely that the highest mortality and the poorest quality of sheep as regards size and constitution are found in the areas where the pastures show the lowest percentage of mineral matter. In Dr. Orr's address to the British Association there occurs this passage:—"It has been suggested that deficiency of calcium may be a causative factor in producing a lowered resistance to tuberculosis. If this is correct, it is of great economic importance on account of the incidence of tuberculosis in dairy cows. It is known that at the height of lactation there is usually a loss of calcium from the body. This is greater the higher the yield of milk, and tuberculosis seems to be more liable to occur in heavy milking cows."

Until more is known of the functions and proper balancing of the minerals in the diet of animals, the safest and most convenient course to adopt is to feed them through the herbage. The mineral elements most commonly deficient are, probably, calcium and phosphorus, and in this connection the application to grass land of phosphates and, where shown to be necessary, of lime as well is of first importance.

PHYSICS IN AGRICULTURE.*

BY

DR. BERNARD A. KEEN.

The study of the physical properties of soil has a fundamental place in the application of science to agriculture. It occupied an important position in the early days of agricultural science, and, after a lengthy eclipse in the latter half of the nineteenth century, when Liebig, Lawes and Gilbert, and others were establishing the modern agricultural chemistry and biology, it again came into prominence, owing to the recognition of the colloidal properties of the soil. The older concepts have been examined from this point of view, and it appears that the soil must be regarded not as a mass of comparatively inert grains over which water is distributed in a thin film, but as particles the surface of which is coated with colloidal material. The composition of this material is complex. It is a mixture of organic and inorganic substances derived from the decomposition of organic matter, and the weathering of clay, respectively, and it modifies very largely the deductions on the relations between soil and its moisture content made from the older hypothesis.

A soil can be easily divided into a few groups or fractions of different average size, depending on the velocity of fall in water. This process is known as mechanical analysis. It is a routine procedure in a soil survey and, combined with ecological and meteorological observations over the area, enables the expert to suggest improvements in the agriculture. In the case of undeveloped countries, this examination is essential if the agriculture is to be built up on sound lines. A striking example of the value of such a survey is afforded by the recent classification of Africa into areas according to agricultural potentialities, made by two American workers. The information was limited and the divisions are only approximate, but the very fact that it was possible to make them at all on such restricted information, shows the power and flexibility of the method.

In research investigations, the simple procedure of mechanical analysis must be replaced by more exact methods, in which the distribution of particles is expressed as a continuous function of the effective radius. One method depends on measuring the gradually increasing weight of particles settling on a pan immersed in a suspension of the soil in water, and from these data the distribution curve can be derived mathematically. The method is not yet perfect, because the settling particles that would eventually reach the liquid under the pan are naturally caught by the

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* Reprinted from *Nature*, No. 2929.

pan, whereas those in the annular space fall freely. In consequence, a density difference is established which sets up currents in the liquid, and the particles are deflected from their proper course.

For the purpose of this work, and for other studies the Soil Physics Department at Rothamsted has developed an automatic and continuous recording analytical balance, illustrated in Fig. 1. A magnet is suspended from one arm, and the current

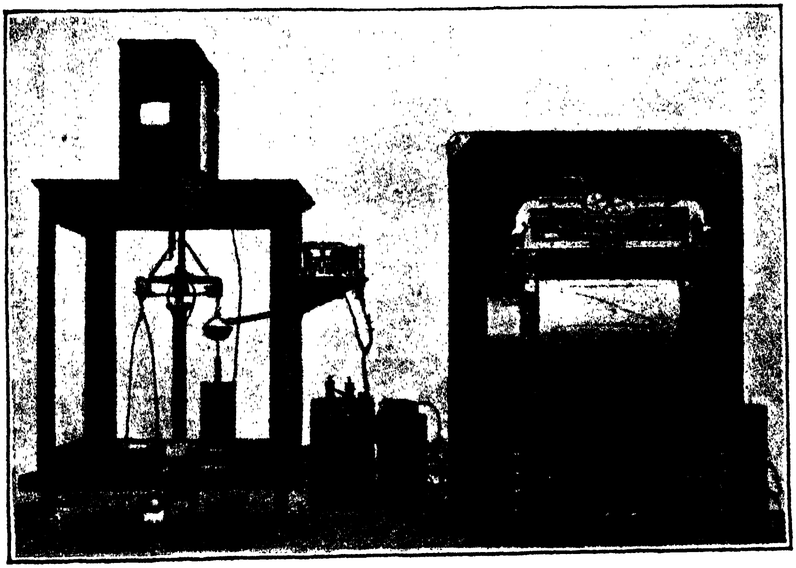


Fig. 1. The Odén-Keen automatic recording balance.

through the solenoid is adjusted to keep the balance in equilibrium. The adjustment is automatic and is effected by using the motion of the balance beam away from equilibrium to complete subsidiary circuits which operate electromagnets controlling clockwork mechanism, that moves a sliding contact backwards or forwards along a slide wire. The current through the solenoid is, therefore, changed by the requisite amount. When the contact reaches the end of the slide wire, a third circuit is completed, and a phosphor bronze ball of known weight is automatically added to the magnet arm. The sliding contact rapidly returns to its zero position and the cycle of operations recommences. The resistances are so arranged that the relation between weight and length of slide wire across which the solenoid is connected is practically linear. Hence a pan attached to the sliding contact and resting on a rotating drum, gives a continuous record from which the change in weight can be inferred.

The treatment of the flow of water through soil, in an analogous manner to the flow of heat or electricity through conductors, presents considerable difficulties,

because the quantities corresponding to conductivity and potential (which for heat and electricity are practically independent of external conditions and current density) are not independent of the moisture content, the state of packing and the colloidal content of the soil. Although the difficulties of theoretical and practical investigation are great, much attention has been devoted to the problem because of the practical applications, especially in areas under irrigation, where it is essential to make the best use of the available water, and yet to avoid the concentration of deleterious "alkali" on the soil surface resulting from an excessive upward movement of soil moisture. In regions with adequate rainfall, recent experiments at Rothamsted indicate that the depth from which water can ascend by capillary action, and thus become available for plant growth, is not very great. This emphasizes the value of those cultivation operations designed to conserve the moisture in the upper regions of the soil.

The importance of the soil water relationships resulted in many additions to the original broad divisions of soil moisture into gravitational, capillary, and hygroscopic moisture. They were based on the assumption that the soil grains could be regarded as inert, but the recognition of the colloidal properties of soil has destroyed the validity and physical significance of these additions. Further, it has been shown that the vapour pressure of moist soil reaches its saturation value at a moisture content well below the values obtained for the so-called "equilibrium points" of soil moisture. This suggests that the moisture relationships are best expressed by other properties of moist soil, such as cohesion and plasticity, because variations in these factors are to be expected at moisture contents above the value for saturation vapour pressure. These properties have the further advantage that they are closely related to the behaviour of the soil under the action of cultivation implements, and they can be readily interpreted on the assumption that the colloidal material in soil forms a coating over the larger inert grains. Thus, the shrinkage of a plastic mass of kaolin, which normally follows a different course from that of soil, can be made closely to simulate the latter if a small amount of silica gel is previously precipitated on the surface of the kaolin particles.

In the field, the integrated effect of plasticity cohesion, and surface friction between soil and a metal surface may be measured by a dynamometer in the hitch between the implement and the horse, or tractor. The drawbar pull thus recorded is found to vary considerably even on areas that to visual inspection are quite uniform. In a comprehensive field test, variations of more than 30 per cent. were found, even when the average drawbar pull of plots 66 ft. × 33 ft. was considered. For individual furrows the differences were much greater. The results are well illustrated by Fig. 2, where the "contours" of equal drawbar pull have been mapped from the results on a scale plan of the field. This variation is of obvious importance in competitive or comparative implement trials, for which, as an essential preliminary, a dynamometer survey should be made of the selected area. Other experiments show that the variations from point to point persist unchanged from season to season,

and are not sensibly affected by manuring, with the exception of organic manures. The variations in drawbar pull figures are also closely related to the amount of drainage and to the early stages of plant growth.

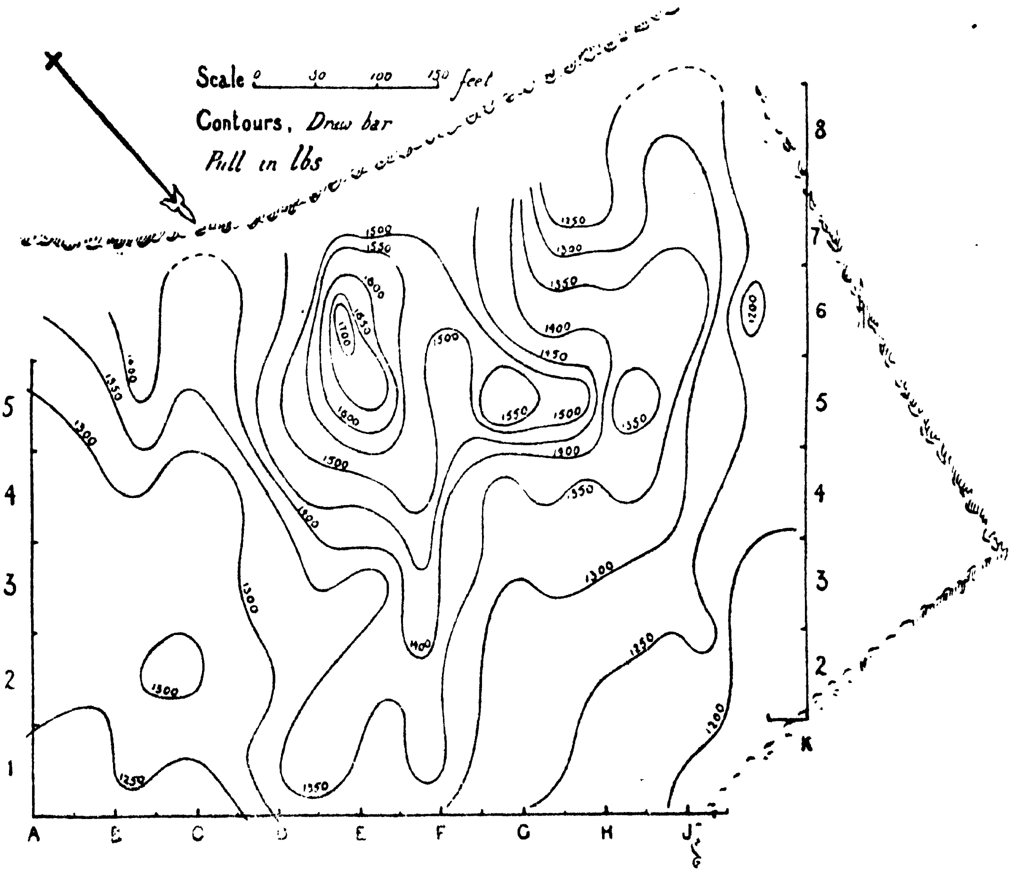


Fig. . Lines of equal draw-bar pull over a supposedly uniform field.

It is found that the drawbar pull is comparatively unaffected by speed of cultivation. Thus for tractor ploughing, an increase from $2\frac{1}{2}$ to 4 miles per hour, which would mean a 60 per cent. greater area ploughed in a given time, only involves a 7 per cent. increase in drawbar pull. It is improbable that the cost of the extra fuel necessary to give this increased pull would be more than a small fraction of the saving in labour costs due to increased speed of work. The design of tractors run at higher speeds without undue wear and tear, and of implements to perform satisfactory work at high speeds, should present no insuperable difficulties,

NOTES

THE ORIGIN OF ALKALI LAND.

In a recent paper in this Journal (Vol. XX, 1925, p. 461) it was suggested that anaerobic bacteria play an important part in the formation of alkali land, and that further work in this direction in India is an urgent necessity. In this connection the following extract from a recent number of *Nature* (Vol. 118, 1926, p. 26) is of interest :—

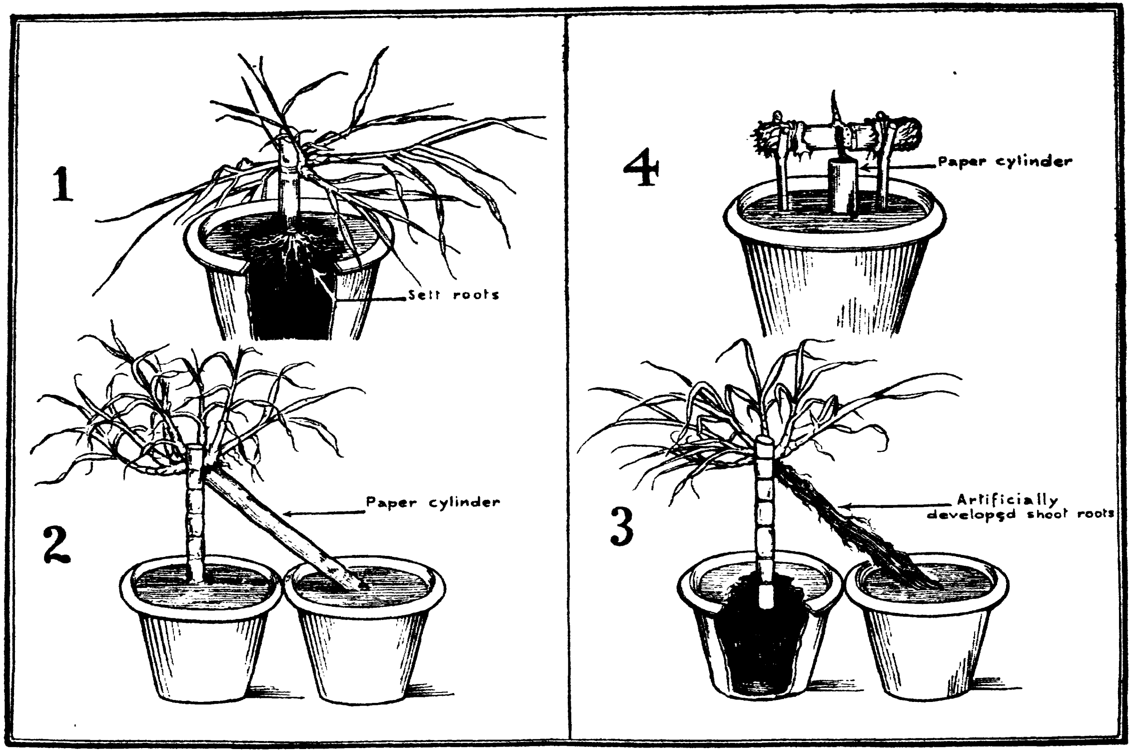
" *The source of hydrogen sulphide in the Black Sea waters.* It has long been known that the upper layers of the waters of the Black Sea only are free from hydrogen sulphide, which is present from the depth of 150 metres downwards, so that no life except bacteria is possible between 150 metres and the bottom (2188 m. in the deepest parts). Nothing was known, however, as to the origin of this hydrogen sulphide, and only recently Prof. B. L. Issatchenko has proved that it is produced from the sulphates dissolved in water by anaerobic bacteria similar to *Microspira æstuans*, known from the northern seas. The Black Sea organism is exceedingly active and can produce so much as 0·3 grm. of hydrogen sulphide per litre of water. Apart from this organism, there are in the bottom mud of the Black Sea some other bacteria able to produce hydrogen sulphide from albumins, but their productivity is far lower and the conditions for it in the depth of the sea are less favourable. Another problem investigated by Prof. Issatchenko was why the surface layers of water are free from hydrogen sulphide. This was formerly ascribed to the presence of an intermediate layer populated by bacteria which are able to oxidise hydrogen sulphide produced in the deeper waters. No such bacteria could be found by a systematic sampling of water, and it is concluded that the oxidation of hydrogen sulphide in the upper layers is due simply to the circulation of water. (*Priroda*, 1925, Nos. 4-6.)" [ALBERT HOWARD.]

A METHOD OF STUDYING THE ROOTS OF SUGARCANE.

INTRODUCTION.

ONE of the earliest changes noticed in a germinating sugarcane set is the development of roots from the root zones. During the very early stages of growth the young cane plant is entirely dependant on these roots. After a time, however, —*i.e.*, after the development of roots from the sprouting buds—the roots from the sets either cease to function altogether or occupy but a subordinate position in the

PLATE XIII.



ARRANGEMENT FOR STUDYING SET AND SHOOT ROOTS IN SUGARCANE.

1. Sugarcane plant growing on set roots alone.
2. Arrangements for artificial production of shoot roots.
3. Artificially developed shoot roots. The set roots have been removed from the bottom node of the vertically planted set.
4. Arrangement for detailed study of set roots. The set is raised from the pot on two supports, and the set roots allowed to develop into a vertically placed paper cylinder. The ends of the set are wrapped and kept moist to prevent their drying up.

future feeding of the plant. The roots developing from the root eyes on the planted set are here designated *set* and, those from the developing shoot, designated *shoot* roots.

Sugarcanes differ in certain characters with reference to the above two classes of roots. While in certain canes the set roots are formed in advance of the sprouting of buds, in others their formation is subsequent to it. The relative development of the two classes of roots has an important bearing on the future growth of the cane plant; and a method, for separately studying the functions of the two classes of roots, was found to be a desideratum.

Ordinary method of germination not quite suitable.

The distinction between the two kinds of roots was first clearly noticed when sugarcanes were grown in culture solutions.[1] To ensure absolutely normal conditions, however, it was found necessary to grow the plants in the soil. Thus grown, the two classes of roots soon get intermingled with one another; and it is difficult to separate them for detailed study. The operations involved in the separation frequently give a certain amount of set-back to the growth of the plant under experiment.

The intermingling of the roots in the ordinary method of germination results largely from the proximity of their places of origin. Secondly, the shoot roots which are periodically produced (from the shoot) during its subsequent stages of growth soon outnumber the set roots; and the latter are quickly thrown into the background. An attempt was, therefore, made to develop a method which would not only separate the places of origin but afford scope for the full development of either class of roots, by suppressing, if necessary, the formation of the other class.

Growing the sugarcane on set roots alone.

A healthy set, of any length and consisting of as many internodes as desired, is selected; and all the buds removed except the topmost one which is left intact. While removing the buds, care should be taken not to injure the root eyes; these may be needed during the future progress of the experiment. The set thus prepared is now planted vertically in pots—and not horizontally, the common practice—burying the bottom node alone in the soil. With the ordinary watering, roots—*set* roots—soon develop from the root zone on the buried node; and the top bud begins to shoot and develop into an ordinary plant (Pl. XIII, fig. 1). In this arrangement the only bud on the set is too far remote from the soil to develop any *shoot* roots; and the growing shoot is fed entirely by the set roots from the buried node.

[1] Venkatraman, T. S., and Thomas, R. Simple contrivances for studying root development in agricultural crops. *Agri. Jour. India*, Vol. XIX, Pt. 5, Sept. 1924.

Growing the sugarcane on shoot roots alone.

A different arrangement is needed for feeding the plant entirely through the shoot roots. At the outset it needs to be mentioned that it has not yet been possible to grow the bud entirely on its own roots from the very commencement. The bud has first to be started on set roots (from the planted set) ; and it is only during its subsequent growth that it can be fed entirely through its own shoot roots.

Planting material is prepared in the same manner as before and sets planted vertically in pots. Some time is allowed for the bud to sprout and shoot with the help of the set roots from the buried node. Paper cylinders—any fairly thick paper will do—are made by gumming the edges together and subsequently dipped in melted paraffin wax ; the paraffining is intended to protect the paper against the frequent watering later on.* These cylinders are filled with soil or saw dust and leaned against the vertically planted set, with the top of the tube touching the base of the now sprouting shoot and the bottom resting on soil (Pl. XIII, fig. 3). The soil at the top of the tube should be in contact with the sprout at its base. Watering the tube from above creates favourable conditions for rooting at the base of the sprout, and roots—*shoot* roots—soon develop.

When the shoot roots have traversed the length of the paper cylinders and reached the soil at their bottom, the set roots from the buried node are carefully removed. After this removal the growing plant obtains its nourishment entirely through the artificially developed shoot roots. Plate XIII, fig. 4 shows the roots thus developed with the paper cylinders removed.

Certain uses of the methods described.

The above methods were developed only in February 1926 and their full possibilities have not yet been ascertained. Certain directions in which the above methods promised to be useful—and experiments are now in progress with most of them—are indicated below :—

(1) Study of the relative functions and importance of the two classes of roots without the risk of their intermingling with one another or one class overshadowing the other.

(2) Study of either class of roots at their fullest development by suppressing, if necessary, the other class.

(3) Detailed study of one or more roots of either class for definite characters such as (*a*) rate of growth, (*b*) longevity, and (*c*) powers of branching and recuperation.

(4) The cane plant could now be thrown for its nutrition on either class of roots and produced from any node, either on the planted set or on the developing shoot, according to the needs of the experiment.

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* The method and use of paraffining paper are detailed in the article on " Labelling in experimental stations " (*Agri. Jour. India*, Vol. XV, Pt. 1, p. 45), by Rao Saheb T. S. Venkatraman.

(5) It is possible to feed the two classes of roots on two different culture solutions. [R. THOMAS.]

SEEDLING CANES IN BARBADOS.

THE Sugar Bureau has received from the Department of Agriculture, Barbados, a report on the sugarcane experiments conducted between the seasons 1923 and 1925 by Professor J. P. d'Albuquerque. The report records the results of experiments carried out on black and red soils with new selected seedlings as compared with the three seedling varieties B.H.10 (12), Ba.6032 and Ba.11569 now generally planted throughout the island and the White Transparent cane. From the results obtained, seedling B. 417 stands out as of greatest practical interest. It gave the highest returns as plant cane in both tons of cane and lb. of sucrose of any of the varieties in both black and red soils. It has not yet been reaped as ratoons. This seedling was grown at the Central Experiment Station at Waterford under irrigation in 1916 from seed obtained from B. 6835.

Some canes have always given evidence of being more useful mothers than others, and B. 6835 is one of them, as, besides being the mother of B. H. 10 (12) and B. 67, it is also a parent of S. C. 12 (4) which is a cane of outstanding merit at the present time in Porto Rico. It will, however, be interesting to mention here that this variety (B. 6835), so rich in the production of valuable offspring, is, curiously enough, not itself one of the best in Barbados as regards its tonnage of cane or of sugar production.

B. 417 is a moderately quick growing cane with spreading, vigorous shoots, with about 12 canes to the clump, of a fairly dark green colour, becoming greenish purple or entirely purple when exposed to bright sunlight. When well grown, the cane reaches a length of 10 to 12 feet, with internodes of 4 to 7 inches, and a maximum diameter of 2 inches, one cane weighing about 12 pounds. The cane normally has a small bud (eye) and arrows readily. The cane is possessed of a rich and pure juice resembling its closely related cane B.H.10 (12).

Another variety of interest is the new series seedling B. 67 which has given slightly higher returns as ratoon canes than any other variety. [KASANJI D. NAIK.]

A HANDY POLLEN CARRIER.

THE artificial hybridization of plants involves the transfer of pollen from the flowers of one plant to those of another, and the degree of success depends in a large measure upon the efficiency of this operation. In the hybridization of cereals, in which work the writers have been engaged for several years, dozens of flowers on several heads frequently must be examined in order to obtain the desired pollen. The anthers are small and must be in just the right stage of development. If gathered too early the pollen will not fertilize; if fully matured the anthers

PLATE XIV.

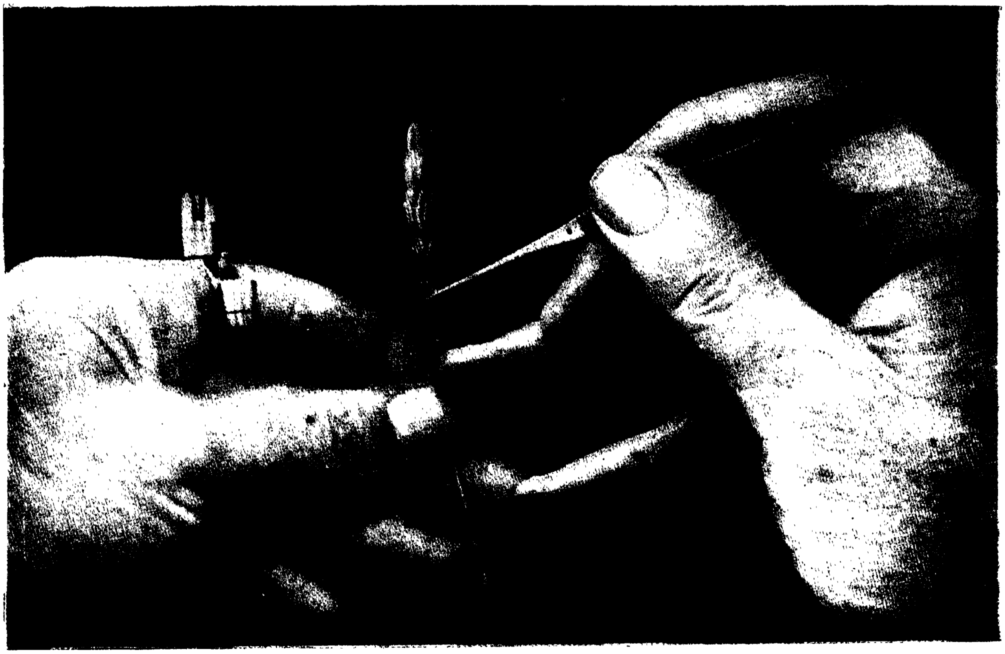

FIG. 1. The pollen carrier in use, showing how the ring with the capsule inserted in the holder is worn in the index finger, while pollen is being collected from a head of wheat during pollination.

FIG. 2. Enlarged view of the pollen carrier. The pollen carrier consists of an adjustable ring fitted with an open cylinder for holding a gelatin capsule and a projection over which the cap of the capsule may be fitted when not in use. Two views of the pollen carrier are shown, with an empty capsule of the kind used shown in the centre.

may burst and lose their pollen. It is highly desirable, therefore, to have some convenient and safe means by which the pollen can be collected and transferred. This is specially necessary in the field where pollen must frequently be transported several hundred yards.

In 1913 one of the writers began the use of gelatin capsules for this purpose, in connection with his work in hybridizing wheat. The No. 0 size was found suitable. The cap was removed and the capsule attached to the thumb of the left hand by means of a rubber band passed twice about the thumb and crossed over the capsule. At times the capsule was simply moistened and stuck to the thumb at the angle desired. A fresh capsule is used for each pollination.

The capsule was found to be quite satisfactory as a receptacle for the pollen, but it was necessary to exercise considerable care so as not to upset it and lose the pollen. There was also some difficulty in keeping it securely attached to the thumb either with the rubber band or by the wetting method.

Several devices for holding the capsules were then tried and finally, one was designed which has been satisfactory in every way. This device, which may be called a " pollen-carrier," is a nickle-plated brass ring, which has been opened at one point and the two ends lipped in order to permit proper adjustment on the index finger. Attached to the interior periphery of the ring on the side opposite the opening is a small, hollow, nickle-plated brass cylinder $\frac{13}{32}$ of an inch long and $\frac{5}{16}$ of an inch in diameter, open at both ends, and cut at one end in such a way as to insure a firm grip on a No. 0 gelatin capsule when one is inserted therein. At another point on the exterior periphery of the ring, above the cylinder which holds the capsule and midway between the point of attachment of the cylinder and the opening in the ring, is attached a solid slightly tapering, nickle-plated brass projection $\frac{9}{32}$ of an inch in diameter and $\frac{5}{16}$ of an inch long. This is designed to hold the cap or smaller part of the capsule which may be slipped over it when not being used to cover the contents of the capsule. This proximity of one part of the capsule to the other part permits easy and rapid closing and opening of the capsule. The ring just described is illustrated in Plate XIV, fig. 2 and the manner in which it is used as a pollen carrier is shown in Fig. 1.

The pollen carrier described and illustrated herewith was made by a local instrument maker at a cost of 1 dollar and the gelatin capsules were purchased from a pharmacist at 20 cents per hundred.

The principal advantages derived from the use of the pollen carrier are as follows :—

1. Free use of the fingers is permitted, while the receptacle is always conveniently placed, thus facilitating the collection of the pollen and its transfer in pollination.
2. Contamination and other injury to pollen being transported from one point to another is prevented by the use of a bi-partite capsule which safely encloses the contents.

3. Sterilization of the receptacle between pollinations is unnecessary, since a gelatin capsule is discarded after being used for one kind of pollen.
4. The method can be used in connection with work on many kinds of plants.

[C. E. LEIGHTY and W. J. SANDO in *Jour. of Heredity*, XVI, No. 2.]

PROHIBITION OF IMPORTS OF MAIZE AND SORGHUM INTO U. S. A.

A REVISION of the quarantine regulations against foreign countries on account of the European corn borer and other dangerous insects and plant diseases has been announced by the U. S. Department of Agriculture with effect from 1st June 1926.

The revision removes the restriction formerly enforced under this quarantine on the entry of certain vegetables, cut flowers and flowering plants from the Province of Ontario, Canada. This action makes the restrictions against Canada on account of the corn borer the same as those imposed by the domestic quarantine against the western portion of the regulated area in the United States. In both these regions the corn borer is single brooded and under this condition there seems to be little, if any, risk that it will infest or be carried by these products. In the New England territory, where the corn borer is double brooded, it infests a considerable list of flowering plants and vegetables, but in regions where it is single brooded its attacks are practically limited to corn and related plants.

The regulations forbid, with the exception of certain provisions, the importation into the United States from all foreign countries of Indian corn or maize broomcorn, sweet sorghums, grain sorghums, Sudan grass, Johnson grass, sugarcane, pearl millet, Napier grass, teosinte, and Job's tears, in the raw or unmanufactured state.

Broomcorn is permitted entry under certain conditions, but even if made up into brooms or similar articles, it must be considered in the raw state unless its manufacture into such articles precludes the possibility of their carrying the corn borer or other dangerous insects and plant diseases.

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

ESTIMATION OF PLANT SAP CHLORIDE.

For use in ecological studies of the variation in plant tissue fluids with environment, the Volhard method is employed for determining the chloride content of plant

saps. The method is applicable to freshly collected and preserved fluids and is well adapted for use in field work. [*Ecology*, 1925, **6**, 391-396. J. V. LAWRENCE and J. A. HARRIS.]

EFFECT OF TIME OF PLANTING ON COTTON PLANT.

In the season of 1923 comparisons were made of the behaviour of early and late plantings in three widely separated parts of the Cotton Belt of U. S. A. The cotton was planted on four different dates and measures were taken to prevent the infestation of early plantings by over-wintered weevils. Differences were shown in the rates of growth and fruiting habits of the plants. A more rapid formation of nodes during the seedling stage was found to occur in the later plantings, resulting in a shorter interval between the date of planting and the appearance of the first floral bud. The fruiting capacity of late-planted cotton was found to equal, and in some cases exceed that of early-planted cotton. The large number of floral buds produced in later plantings was due to the fact that more nodes were produced on the lower fruiting branches. Also, slightly larger numbers of flowers were recorded on the late-planted cotton, although early plantings produced a larger number of flowers during the first part of the flowering period. A separate late planting made at San Antonio showed that thinned plants had a larger individual fruiting capacity than unthinned plants, the difference being counterbalanced, however, by the greater number of plants in the unthinned rows. *U. S. D. A. Bull.* 1320, 1925, 43 pp. [W. W. BALLARD and D. M. SIMPSON.]

MANURING OF COTTON PLANT.

Greenhouse experiments on the rate of absorption by cotton of nitrogen applied in the form of sodium nitrate are described. The nitrate was applied at the rate of 600 lb. per acre, 14, 40 and 61 days after planting and absorption was complete in 36, 14 and 11 days, respectively. Thus, when nitrate is applied to cotton 14 days after planting the plants are not sufficiently developed to absorb it rapidly and considerable amounts may be lost by leaching. Such loss may be diminished considerably delaying application to a later stage of growth. *Jour. Amer. Soc. Agronomy*, 1925, **17**, 596-605. [W. H. APPLETON and H. B. HELMS.]

EFFECT OF BOLL WEEVIL ON YIELD.

The situation resulting from the gradual extension of the cotton boll weevil over the cotton crop from the south-west of Texas to Virginia during the past 30 years is reviewed, an analysis of the position in each State being given. An examination of the facts shows that no State, after infestation, has been able to regain its former yield per acre (with the possible exception of Oklahoma in 1924). Most of the States would be obliged to double their acreage in order to obtain the same productive yield as under pre-weevil conditions. Experience has shown that there

is no profit to the grower unless at least half a bale of cotton per acre can be produced, and during the years 1920-24 the cotton States showed an average yield of one bale per 3·2 acres. It is suggested that the future production of cotton must be undertaken on a restricted acreage and a highly intensive system of cultivation. The average farmer cannot successfully cultivate and handle more than 5 to 7 acres under cotton per plough under boll weevil conditions. Demonstrations of cotton growing have proved of incalculable value and well worth the outlay entailed. [*Rev. Appld. Ent.*, 1925, **13**, 504; from *N. Y. Commercial*, July 7th, 1925. H. JORDAN.]

PINK BOLLWORM IN AUSTRALIA.

Two well defined races of *Platyedra gossypiella* are established in Queensland, one occurring on species of wild *Hibiscus* and not having been found on cotton. It differs from the typical form in being more deeply and evenly coloured in the crotchets of the forelegs forming a pattern of two opposite arcs and not a complete horseshoe, and in the very marked chitinisation of the setiferous plates. The larvæ from Western Australia and the Northern Territory belong to the typical form. The present situation in Queensland is reviewed. Only three gins are in use, so that a fairly good record can be kept of any new areas which become infested. Vigorously applied legislation, or co-operation on the part of the farmers would keep the pest in check, but in present circumstances it can only be hoped to prevent its spreading to uninfested areas. [*Rev. Appld. Ent.*, 1925, **13**, 518; from *Jour. Econ. Ent.*, 1925, **18**, 641-642. E. BALLARD.]

CAUSES OF STAINED COTTON.

Staining is a result of internal boll rots, due to fungi, chiefly *Fusarium moniliforme*, and bacteria, which enter when the boll is punctured or similarly damaged. Such damage may be due to the attacks of *Heliothis obsoleta*, *Dichocrocis punctiferalis*, *Earias huegeli*, *Platyedra gossypiella*, *Crocidosema* (*Eucosina*) *plebeiana*, *Tectocoris banksi* or *Dysdercus sidæ*. The destructive powers of the last two are often underestimated. *T. banksi* feeds equally readily on the seeds of open bolls, on the green bolls or on the leaves, whereas *D. sidæ* is generally found in open bolls, preferring to feed on cotton seed, but once it is attracted to the field it may be found on both ripe and unripe bolls. In experiments in which examples of these species were confined individually in healthy bolls staining resulted in a large number of cases to an extent which would have penalized the cotton at least 50 points on the Liverpool market. As regards damage done by *T. banksi*, in one 30 acre field 50 per cent. of the green bolls were infected with boll rot, 27 per cent. more with boll rot and *D. punctiferalis* and 6 per cent. with *P. gossypiella*, in some cases together with boll rot. No suitable control method for *D. sidæ* under Queensland conditions has been evolved. Hand collection of all stages of *T. banksi*, including the egg-

masses, should be done thoroughly and started early. [*Rev. Appld. Ent.*, 1925; **13**, 520; from *Queensland Agri. Jour.*, 1925, **23**, 542-545. E. BALLARD.]

DESCRIPTION OF PIMA COTTON GIN.

The varied appearance of baled Pima cotton has been due to the mechanical condition of the cotton caused by the diversity of roller ginning methods in use in Arizona and not to any lack of uniformity in the cotton itself. The need for uniform methods in the ginning and handling of cotton is emphasized, and an attachment for removing the lint from the gin roller in a way that straightens the fibres and improves the appearance of the cotton is described. The device consists essentially of the replacement of the brush which takes the cotton from the gin rollers by a rapidly revolving auxiliary wooden roller provided with six flexible flaps projecting about ¾ inch from the surface of the roller. By this method the cotton is taken from the gin roller without being folded or rolled and falls behind the gin in a smooth, fluffy and uniform condition. [*U. S. D. A. Bull.* 1319, 1925, 11 pp. J. S. TOWNSEND.]

COTTON BOLLWORMS IN CYPRUS.

Considerable damage to cotton bolls has been caused in Cyprus by *Earias insulana* and *Platyedra* (*Gelechia*) *gossypiella*. The life-histories of these moths are outlined and the measures against them ordered by the Government are described. The date on or before which growers are required to destroy all cotton, etc., is to be fixed annually and will probably be about 15th October. [*Rev. Appld. Ent.*, 1925, **13**, Series A, 322; from *Cyprus Agri. Jour.*, 1925, **20**, 64-66. D. S. WILKINSON.]

COTTON JASSIDS IN FRENCH SUDAN.

Jassids are among the most dangerous of the less known pests of cotton, the chief being *Empoasca devastans* and *E. notata* in British India, and *Chlorita facialis* in South, East and West Africa. In plantations infested by Jassids, the leaves become deformed and fall, growth ceases and the plant may die. Leaf roll has already been shown to be caused by *C. facialis* in East Africa; infected leaves become cup-shaped and there is a close relation between the spread of bacterial rust of cotton and of mosaic disease and the increase of this insect. Colonies of *C. facialis* live on the lower surface of leaves about the base of the principal veins. In the Niger Valley, this leaf hopper attacks native cotton less than American or Egyptian varieties. In the French Sudan the development of the insect takes from 20-24 days in October and is more rapid in the dry season. Incubation seems to require only 9 days and the adult stage is reached in another 9 or 10. Damage appears to be much less severe on ground containing mineral fertilizers especially potash. Spray experiments have been made but so far are inconclusive. [*Rev. Appld. Ent.*, 1925, **13** Series A, 74; from *Rev. Bot. appld. and Agric. colon.*, 1924, **4**, 757-759. J. VUILLET.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE New Year's Honours List contains the following names which will be of interest to the Agricultural Department:—

C.I.E. . . . Mr. R. D. Anstead, M.A., Director of Agriculture, Madras.

Mr. D. Milne, B.Sc., Director of Agriculture, Punjab.

Rao Bahadur . . . Mr. D. L. Sahasrabuddhe, M.AG., M.Sc., Agricultural Chemist to Government, Bombay.

We regret to record the death of Captain G. G. Howard, M.R.C.V S , Deputy Director of the Civil Veterinary Department, Bihar and Orissa.

DR. F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S., Officiating Imperial Economic Botanist, Pusa, has been granted leave on average pay for seven months from 21st March, 1927. Khan Sahib Abdur Rahman Khan, First Assistant, will be in charge of the current duties of the post of Imperial Economic Botanist, in addition to his own.

MR. H. COOPER, M.R.C.V.S., Pathologist, Imperial Institute of Veterinary Research, Muktesar, has been granted leave for 8 months from 1st April, 1927. Mr. M. B. Menon will remain in charge of the current duties of the post.

MR. J. N. SARKAR, M.S.A., Officiating Deputy Director of Agriculture, Northern Circle, Bengal, has been transferred to Calcutta to hold charge of the Western Circle.

MR. A. R. MALIK, M.A., B.Sc., has been temporarily appointed to hold charge of the office of Deputy Director of Agriculture, Northern Circle, Bengal.

MR. R. C. BROADFOOT, N.D.A., C.D.A., Officiating Cotton Specialist, Madras, has been granted combined leave for nine months from the date of relief.

MR. T. F. MAIN, B.Sc., Deputy Director of Agriculture, South Central Division, Bombay, has been granted combined leave for six months from 28th January, 1927. Rao Saheb B. P. Vogholkar has been appointed to act for Mr. Main during the latter's absence.

MR. B. S. PATEL, B.AG., N.D.D., N.D.A., Professor of Agriculture, Agricultural College, Poona, has been granted leave on average pay for eight months from 25th March, 1927.

MR. V. G. GOKHALE, L. AG., Deputy Director of Agriculture, Konkan, has been appointed to act as Professor of Agriculture, Agricultural College, Poona, *vice* Mr. B. S. Patel granted leave.

RAO BAHADUR P. C. PATIL, M. Sc., L. AG., Officiating Principal, Agricultural College, Poona, has been granted leave for 3 months and 10 days from 22nd March, 1927.

MR. C. TADULINGA MUDALIYAR has been confirmed as Government Lecturing and Systematic Botanist, Madras, in the Indian Agricultural Service with effect from 3rd September, 1926.

DR. H. E. ANNETT, D.Sc., F.I.C., Officiating Agricultural Chemist to Government, Central Provinces, has been confirmed in that appointment with effect from 10th September, 1924. He has been granted combined leave for two years and four months from 30th January, 1927.

MR. MUHAMMAD ISMAIL MALIK, B.Sc., M.R.C.V.S., has been appointed temporarily as a special officer in the Civil Veterinary Department for one year from 1st December, 1926, and attached to the office of Director, Civil Veterinary Department, Bihar and Orissa.

REVIEWS

Plant Products.—By S. HOARE COLLINS and G. REDINGTON. Pp. 251. (London: Baillière, Tindall and Cox.)

THE senior author of the book is well qualified to write on agricultural chemistry. He was formerly Assistant Agricultural Chemist to the Government of India and for many years since has been on the staff of the Armstrong College.

The book forms one of a series on industrial chemistry. It is stated that the books of this series are intended to present a summary of our knowledge of the particular subject dealt with in such a way as to be useful to men of affairs having no special technical knowledge who do not want the details given in the larger standard works. The books are also intended for the advanced student as a general guide to the individual industry concerned as a whole and as an adjunct to his ordinary text-books, and also as a guide to the standard literature of the subject.

A first volume of the work under review appeared in 1918 under the title " Plant Products and Chemical Fertilizers." This volume gave signs of hurried compilation and has been replaced by the publication of " Chemical Fertilizers " in 1920 and by the present volume. The book is divided into four parts dealing with fertilizers, soils, crops and animal feeding, respectively, the last part also including dairy products as a sub-section. The first part gives a good general sketch of our knowledge of fertilizers which may be useful to the layman, but the advanced student will find nothing here which is not well set out in the standard text-books. Moreover, since the subject matter is dealt with in the companion volume " Chemical Fertilizers " there seems no need for its treatment in this book. The authors state that tetra calcium phosphate occurs in basic slag. This is not in accord with our present knowledge.

The same general remarks apply to Part II which deals with soils. As a superficial sketch it may be useful to a certain class of reader but will add little to the knowledge of the agricultural student. The authors' statement that " the soil consists of hard particles surrounded by a colloidal jelly with loosely combined elements of plant food " is hardly what should be taught to advanced students. Recent work indicates that much colloidal matter exists in soils apart from any that may surround hard particles, and Joseph's recent work in Egypt shows that the colloid content of a soil is frequently almost exactly equal to its clay content.

The best portion of the book is undoubtedly Part III which deals with crops. It gives a sound but brief sketch of photosynthesis and of nitrogen assimilation and metabolism. It also gives interesting facts concerning many of the important

agricultural plants of the world. In particular the nitrogenous constituents of plants are well treated. The last part of the book deals with the use of plant products as food. In the sub-section of this dealing with food fed to beasts one would have liked to see rather fuller reference to the recent important work on mineral nutrition of animals. This sub-section generally will not be of much use to the advanced student. The subject of dairy products is dealt with in 3½ pages and provides no new matter.

One's general impression of this book is that it is a mere sketch of the subject, and that the agricultural student will find most of the subject matter better treated from his point of view in the existing standard text-books.

The title of the book hardly seems correct since it is really a sketch of agricultural chemistry. The parts dealing with manures and soils might well be omitted and Parts III and IV expanded and the book renamed " The Plant : Its Products and their Utilization." There would be a much greater demand for a book of this type.

The book has interesting features and includes a well selected list of references and a general bibliography. It will form a useful addition to agricultural college libraries. [H. E. A.]

Agricultural Marketing.—By JOHN T. HORNER. Pp. viii+249; 46 figs. (London : Chapman and Hall.) Price 12*s*. 6*d*.

MARKETING of agricultural products presents a first class problem of study in Indian agriculture. But, unfortunately, very little attention is paid to this part of agricultural economics, even though there is every likelihood of increasing the returns of the producer by improving the essential marketing services and eliminating and discouraging those which are not so necessary.

The general illiteracy of the agricultural masses who form the bulk of the producers and consumers, their pitiable and helpless condition, the defective transport facilities in the interior of the country, the different systems of weights and measures are the great stumbling blocks in the organization of efficient marketing services. The Indian village is no longer in the self-sufficing agricultural stage. In modern days, scarcely a family or an individual escapes the good or bad effects of a marketing system. The activities of the consumers and the producers are in a great way determined by marketing systems and agencies.

The system of weights and measures in India, for example, is simply appalling. It is very difficult even for an educated man to follow the different weights and measures prevailing in the country. Recently, a dairy expert, who proposed to start a milk supply in Bombay, spent several days in the city trying to discover an exact equivalent of a Bombay milk seer in English terms. The answers which he got from Government and business authorities were conflicting, and there was

an appeal made to the public through the *Times of India* to solve the problem. No one was able to say exactly what a milk seer was, and the expert left Bombay remarking that in his travels all over the East, India and China were the only two countries in which he found the people ignorant of the value of their own weights and measures.

In the absence of a special book on marketing of farm products in India, the one under review should prove a valuable guide in the study of intricate problems of the Indian agricultural marketing system.

The author in his preface says that " the whole problem of marketing is so complex that a thorough discussion of it would lead one into almost all phases of economic and social life .... The book is not a complete discussion of the subject, but rather, it is hoped, a contribution, which will aid the student and the general reader to secure a better understanding of the economics of marketing." Hence, as he says, " no attempt is made to explain the existing marketing machinery ......" The author has laid special emphasis on " problems of demand, producing for the market, marketing wastes and the economic basis of marketing services." Most of the book is thus a theoretical treatise and will make an excellent reading for students of economics.

In fully discussing the advantages of standardization of farm produce, the author quotes some lines from the Report of the American Associations' Committee on Co-operation, which describes conditions analogous to ours :—

" United action is necessary. Individuals in districts held to be inferior cotton districts have repeatedly produced superior cotton......... However, since their market price is based on the character of the bulk of the local crop, they are often discouraged, through failure to receive the price which their product justifies, from continuing their efforts for the growth of superior cotton, and so revert to the growth of inferior variety. .... To establish a reputation of a section for superior cotton there must be annually a dependable quantity of such cotton available in the markets of that section."

Similar difficulties were met with, by the Bombay Agricultural Department, while introducing improved cotton strains in Gujarat, Khandesh and Karnatak. Efforts are now being made by the Agricultural Department to establish certain strains on a large scale in definite tracts and the results are very encouraging.

In treating the " financing of agricultural marketing ", the author remarks that the " method of sale to local buyers immediately after harvest time has been considered the one great weakness of our agricultural marketing system. Lower prices have been the result of this method of sale." Under the prevailing conditions, this does not seem to hold good in the Deccan and Khandesh. Observations show that it does not pay the peasant to haul his produce to primary markets. After fully describing the difficulties of financing agricultural marketing, the author concludes that co-operative credit is one of the most efficient means of improving

agricultural finance. This statement is borne out under our conditions and is seen by the work carried out near Poona where the sugarcane farmer is financed by local credit societies and the produce sold through the Central Haveli Gul Sale Society. Dealing with marketing weaknesses and their remedies, the author says "...... with the present organization of an economic machinery every man is going to get the greatest profit he can. Lack of information makes it impossible for a seller to be on equal terms with the buyer who has information concerning the market. The farmer is not beaten in the market place, because he is a farmer, but because he does not know about markets and market conditions...............Improvement in marketing is vitally connected with improvement of production."

The last pages of the book are devoted to show the defects of the agricultural marketing system and to suggest remedies which can be undertaken by farmers, dealers, consumers and the Government. The author concludes the book with an appeal for a "more thorough study of the (marketing) problem (which) will greatly help farmers, dealers, consumers and the Government to facilitate marketing. Such a study must be scientific and free from preconceived ideas, bias, prejudice or class interest." [P. C. P.]

Canning and Preserving.—By S. K. Mitra, M.S., Ph.D. (Calcutta : Thacker, Spink & Co.) Price Rs. 4.

This publication is illustrated both by photographs and drawings and is in fact a rare contribution of its type in India, and is quite timely to meet the necessities of the present moment, when efforts are being made in various parts of the country to popularize the subject of canning and preserving. But as the author himself admits, it only deals with the subject in a "simple style." It will be read with great interest even by a layman and will be found a substantial addition to the library of every agriculturist, setting forth as it does, all important principles of canning and preserving and a large number of recipes for the preparation of juices, jams, chutneys and several other products. It will serve as a good guide not only to commercial men but also to amateurs who want to utilize their surplus produce of fruits and vegetables for the manufacture of various by-products in a systematic way.

Its usefulness can be greatly enhanced if certain items, as for instance, the application of Kieselghur in the clarification of juices, treatment essential for bottling different juices, blending of juices, drying by artificial heat, and sulphuring of vegetables are properly explained, and the descriptions amplified by references to recent publications on food conservation.

On the whole, this is a useful publication and will be of great value to those who wish to start or are attached to fruit and vegetable farms. [G. S. C.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Dairy Cattle : Selection, Feeding and Management, by W. W. Yapp and W. B. Nevens. (London : Chapman and Hall.) Price 11*s*. net.
2. The Production of Cotton, by Gilbeart H. Collings. (London : Chapman and Hall.) Price, 17*s*. 6*d*. net.
3. The Cultivation of Citrus Fruits, by H. Harold Hume. Pp. xxi+561. (New York : The Macmillan Co.) Price, 21*s*. net.
4. Manual of Plant Diseases, by F. D. Heald. Pp. 891 ; 272 illus. (London : McGraw-Hill Publishing Co.) Price, 35*s*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs

1. A Study of Absorption of Moisture by Soils, by J. Sen, M.A., Ph.D., and Bhailal M. Amin, B.A. (Chemical Series, Vol. VIII, No. 12.) Price, As. 6 or 9*d*.
2. The Selection of Burma Beans (*Phaseolus lunatus*) for Low Prussic Acid Content, by J. Charlton, M.Sc., F.I.C. (Chemical Series, Vol. IX, No. 1.) Price, As. 10 or 1*s*.
3. Bangalore Maintenance Experiments, First Series, by F. J. Warth, M.Sc. (Chemical Series, Vol. IX, No. 2.) Price, As. 11 or 1*s*. 2*d*.
4. Experiments on the Treatment of Hookworm Infection in Dogs, by Amarnath Gulati, M.Sc. (Veterinary Series, Vol. VII, No. 7.) Price, As. 11 or 1*s*. 3*d*.
5. On the Occurrence of a Lung Fluke *Paragonimus edwardsi*, n. sp. in a Palm Civet (*Paradoxurus grayi*) in Kumaon Hills, by Amarnath Gulati, M.Sc. On the Occurrence of *Isospora* and *Balantidium* in Cattle, by Hugh Cooper, M.R.C.V.S., and Amarnath Gulati, M.Sc. (Veterinary Series, Vol. III, Nos. 8 and 9.) Price, As. 4 or 6*d*.
6. Sugarcane Breeding—Indications of Inheritance, by Rao Saheb T. S. Venkatraman, B.A. (Botanical Series, Vol. XIV, No. 3.) Price, As. 8 or 10*d*.

ORIGINAL ARTICLES

ARTIFICIAL AND NATURAL ASIATIC-AMERICAN COTTON HYBRIDS.*

BY

G. S. ZAITZEV,

Director of the Turkestan Plant-breeding Station, Tashkent.

Some biological peculiarities of the blooming of the cotton plant observed by the author and especially the mechanical rupture of the style soon after blooming, caused him to suppose the possibility of obtaining a hybrid between the Asiatic and American cotton plants, in spite of the fact that previous and rather numerous experiments conducted by the author on the same question led to entirely negative results. Experiments[1] recommenced in 1920 and, when proper measures had been taken to remove the mechanical impediment hindering the penetration of foreign pollen tubes to the ovules, gave definite indications, that in the case of fertilization of emasculated flowers of the Asiatic cotton (*G. herbaceum* L.) with the pollen of the American cotton (*G. hirsutum* L. and *G. barbadense* L.) the development of the ovaries to the size of normal bolls takes place in most cases, as well as the formation of the hybrid embryos. These embryos, however, always appeared to be insufficiently developed and growth stopped at the earliest stages of their development. Examinations of the embryo sack of the hybrid ovules showed either a very early disappearance of the endosperm or a very slight development of it. The absence of the endosperm makes me suppose that the insufficient development of the embryos may be partly the result of their starvation. The formation of the embryo seems to be the first stimulus resulting in the development of the ovaries. This stimulus, however, seems to be insufficient, and the following interruption in the development of the embryo checks the further development of the ovaries also; they begin to dry up gradually, and at last, reaching a quite mature stage, they either fall off or dehisce, revealing the seeds which are approximately normal in size, as far as one can judge from their appearance, but are completely empty, save for a microscopical embryo, situated near the micropyle.

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* Received for publication on 4th February, 1927.

[1] *Agri. Jour. India*, Vol XX, No. 3, May 1925, p. 213; and Vol. XXI, No. 6, November 1926, p. 460.

As the result of numerous experiments it was possible to suppose that a fully developed hybrid seed could be formed under some favourable, quite accidental, circumstances, when—on one side—a quite normal endosperm is formed, able to feed the hybrid embryo, while, on the other side, a formation of such a hybrid embryo could take place, that would be more capable of living, owing merely to its constitution. Crosses made in 1921 justified this supposition: in one of the bolls obtained from crossing *G. herbaceum* L. (No. 454) with *G. hirsutum* L. (No. 221) among the abnormal empty seeds, a perfectly normal healthy seed was obtained, that distinctly showed at germination, in the spring of 1922, its hybrid origin by the absence of the short hairs characteristic for the hypocotyl of the female parent—*G. herbaceum.* A complete description of this hybrid (I) and of its parental forms will be found below. The success obtained compelled me to repeat the experiment on a rather larger scale in 1922, and, as a result, a second artificial hybrid (II) between *G. herbaceum* and *G. hirsutum* was obtained in the 1923 sowing. Summarizing the results of all the experiments conducted on crossings between Asiatic and American cottons during the last three years, when the two hybrids (I and II) were obtained, we may come to the following general conclusions, deduced from observations of the process of producing them :—

(1) The above-mentioned rupture of the style is the first difficulty of crossing Asiatic cottons with American ones.

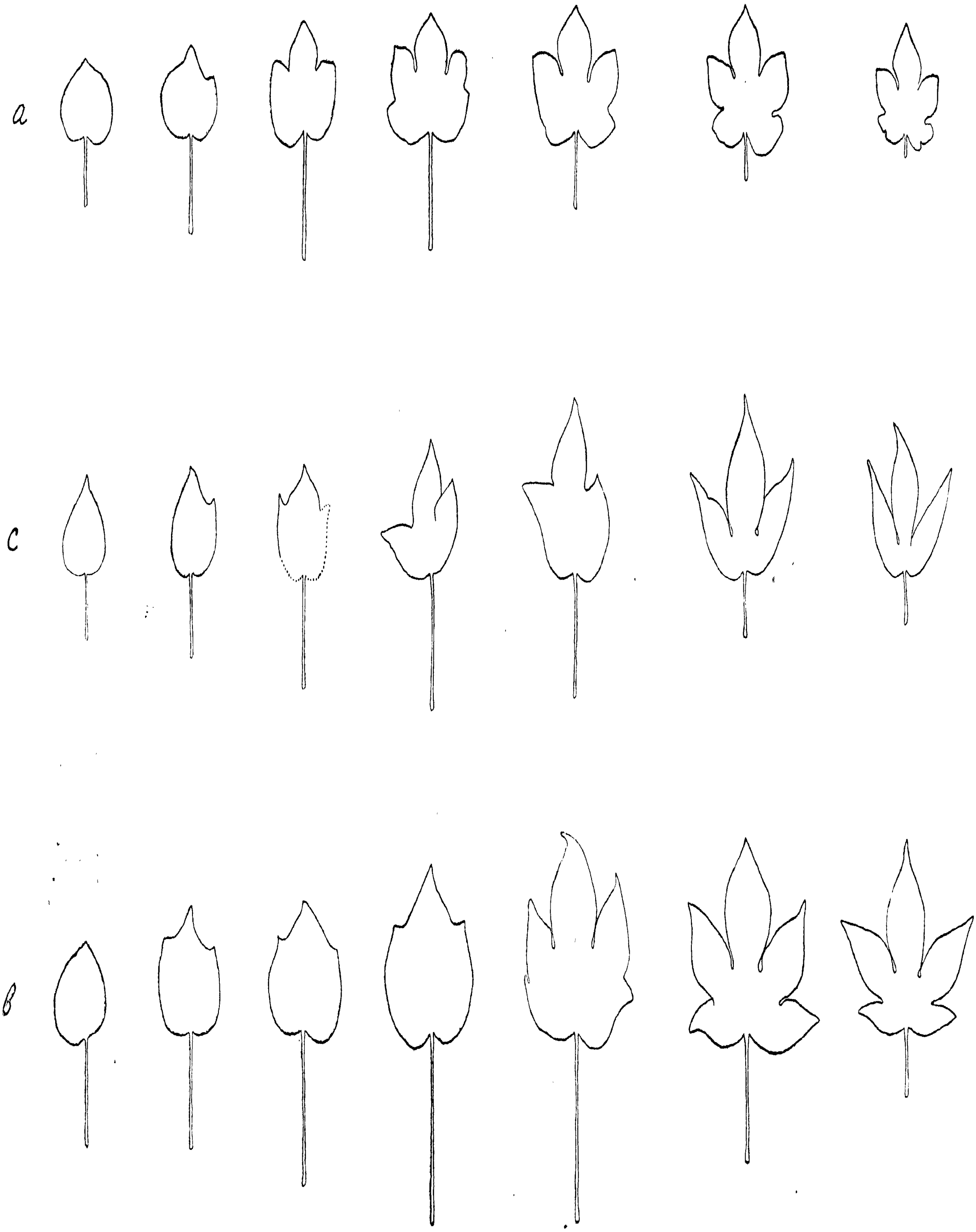
(2) The removal of this check, which can be achieved by the complete removal of the whole corolla from the style before pollination, leads in most cases to the formation of hybrid embryos, and at the same time to an almost normal development of the ovaries.

(3) In the majority of cases, however, the young developing bolls stop growth and dry up, partly falling off and partly dehiscing before the due time. Only an insignificant number of bolls reach complete development, and even these bolls, when opened, always revealed abnormal " empty" seeds. From all the crosses made (more than 1,000 in number) only two normally-developed hybrid seeds were found at different times, in similar better developed bolls, and from these seeds the undermentioned hybrids (I and II) were obtained.

(4) In all the investigations on the development of hybrid seeds not only was a slight development of the embryo shown, but also a very slight development of the endosperm, or even a complete absence of it.

(5) Hybrids between Asiatic and American cottons were obtained when the Asiatic cotton (*G. herbaceum*) was taken as the female parent. Similarly, in all the crossing experiments the fact was observed that pollination of the Asiatic cotton with pollen of the American cotton lead more often to the formation of well developed ovaries (though with empty seeds) than in the reciprocal crosses when the pollen of the Asiatic cotton was applied to the stigma of the American cotton.

PLATE XV.



The shape of seven first leaves along the main stem. *a*, ♀ 454 (*G. herbaceum*); *b*, F_1 ♀ 454 × ♂ 221; *c*, ♂ 221 (*G. hirsutum*)

PLATE XVI.

The shape of the leaves of the main stem at the 10th sympodial branch. a, ♀ 454; b, ♂ 221; c, F_1 ♀ 454 × ♂ 221.

(6) One prominent distinguishing feature of the hybrids obtained was their complete sterility, not only in respect to self-fertilization but also to fertilization with pollen of the parents and of many other forms—and this though the general development of the hybrids and their flowering did not show any abnormalities.

The results obtained seemed to afford sufficient evidence of the impossibility of the cottons of the New and Old Worlds exercising any influence on each other. This led me to abandon further attempts to cross these two separate groups and the interest demonstrated by the hybrids might be considered as exhausted. However, in the 1924 field collection, in a family of the variety No. 289 of *G. herbaceum*, one of the author's assistants, quite unexpectedly, found a plant representing a natural hybrid of the variety No. 289 with *G. hirsutum* No. 182. In the preceding year (1923) the variety No. 289 was grown in close contact with a standard row of No. 182 (*G. hirsutum*). Evidently, the hybrid obtained was a result of the activity of insects which carried the pollen of No. 182 to the stigma of No. 289. This instance of a natural cross of *G. herbaceum* with *G. hirsutum* appeared to be especially interesting as it indicated the possibility of hybridizing these cotton types, firstly in the presence of the female parent pollen, and secondly though accompanied by the usually inevitable rupture of the style.

Certainly, the latter circumstance, *i.e.*, the rupture of the style, does not always take place (in Asiatic cottons), and there are some cases when the corolla being torn off does not tear the style; but the first condition, *i.e.*, the presence of the female parent pollen, must be still considered as inevitable. It was possible to believe that the presence of the female parent pollen and the formation of normal seed have a special positive value for the development of the hybrid embryo. We have been especially convinced in this by the fact that in the summer of 1926 in a plot of *G. herbaceum* strains No. 454 and No. 3258 new hybrids were found. Variety No. 454 was grown in 1925 in close contact with plants of the standard variety No. 182 (*G. hirsutum*) (in order to fill up empty spaces in plots of *G. hirsutum*). In the same year, at our sub-station in Ferghana a hybrid with *G. hirsutum* was also found in a variety of *G. herbaceum*. Thus it became clear that there were better chances of obtaining hybrids between *G. herbaceum* and *G. hirsutum* when these were grown in close contact under natural conditions than by artificial cross-fertilization. The above-mentioned natural hybrids of *G. herbaceum* with *G. hirsutum* are described under the Nos. III, IV, V, VI and VII and for comparison parallel descriptions of the female parents are given below.

Descriptions.

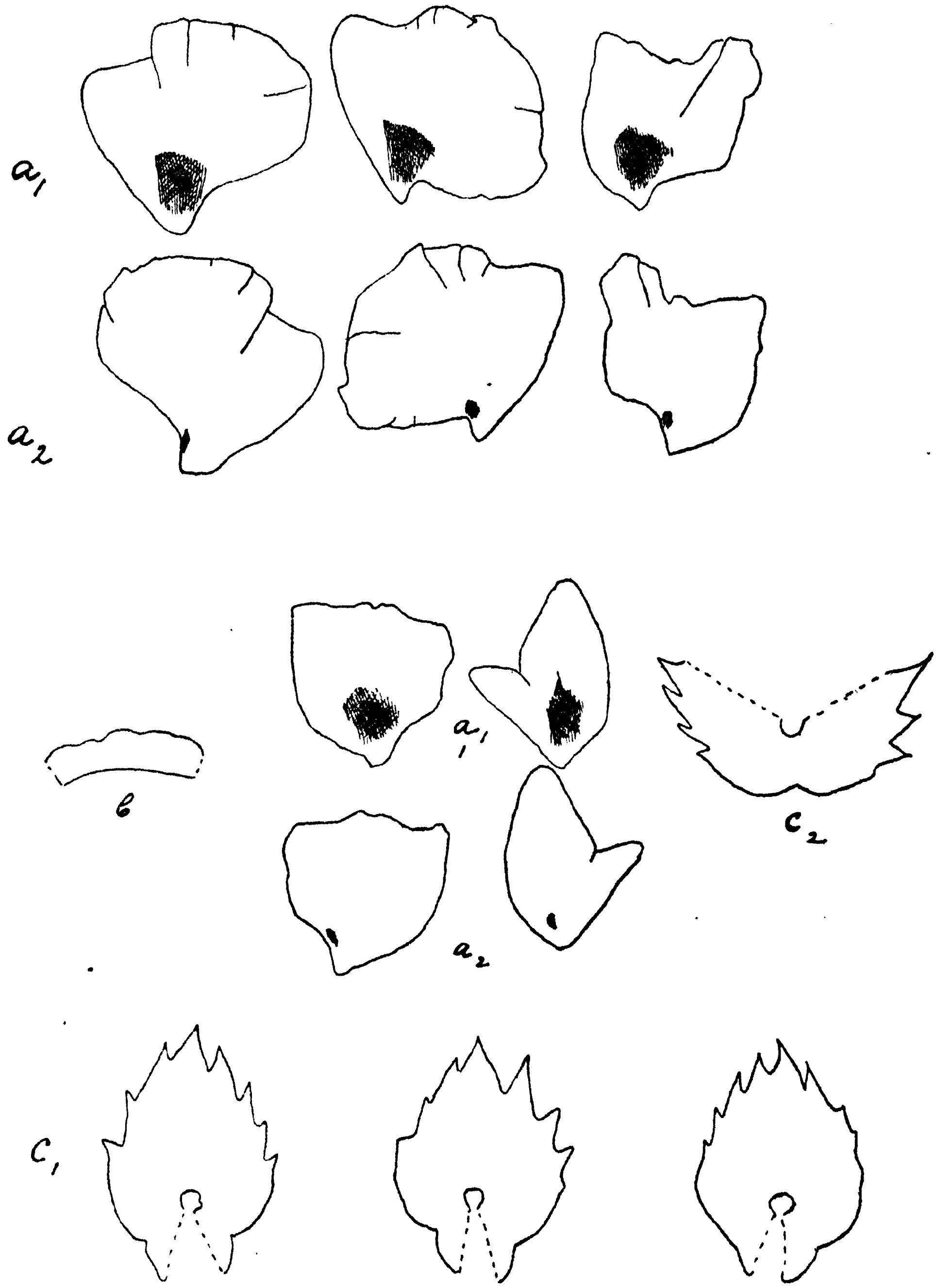
I. The artificial hybrid ♀ 454 (G. herbaceum) × ♂ 221 (G. hirsutum L. var. laciniatum Zaitz.).

The main stem and branches. The main stem is 287 cm. high. It is covered with a single layer of a few long hairs (about $2\frac{1}{2}$ mm.). The colour of the stem is

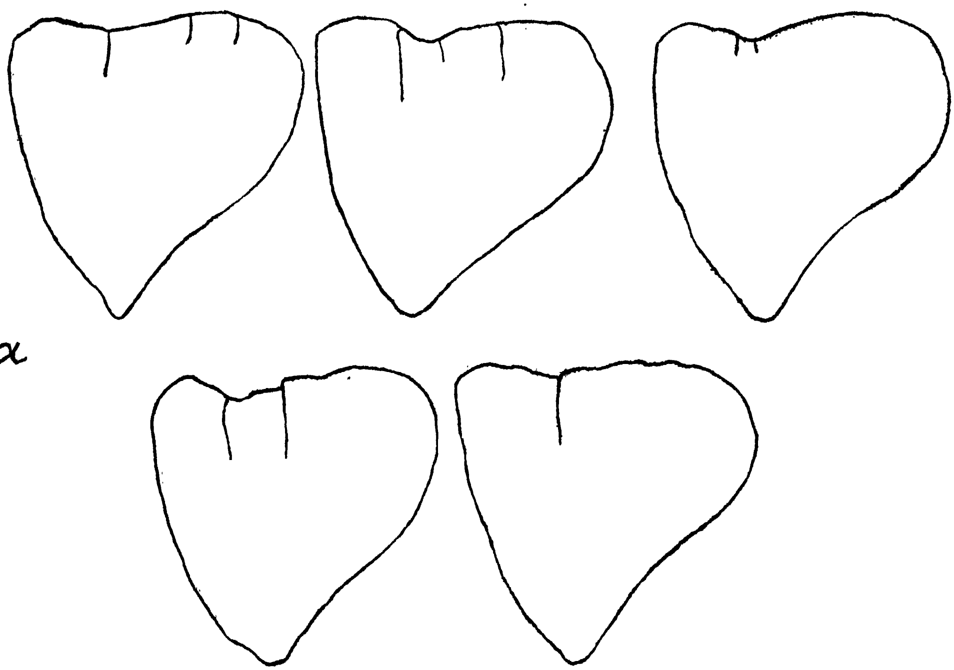
dark red on the exposed parts, green on the opposite parts, and covered with minute dot-like glands (gland dots). Three large monopodial branches are developed from the main buds on the lower part of the stem, and 14 monopodia of different size (Pl. XXI) are developed from the accessory buds. The main sympodia (38 in number) begin from the 6th node; the accessory sympodia (8 in number) begin from the 19th node and are relatively well developed with the exception of the first one (Pl. XXI). The sympodia (fruit-bearing branches) are very long (owing to the great number of internodes) with considerably long internodes. The first internode of the sympodia in the middle of the plant equals in length two internodes of the main stem. In respect to pubescence and colour the sympodia are similar to the main stem. The sympodial branches have shown in many cases the development of shortened sympodia from the accessory buds.

The leaves. If we express a simple 3, 5 or 7-lobed leaf respectively by the symbols O, A, B and C (the intermediate single leaves can be expressed by two symbols) and the teeth of the lobes by the symbol *d*, the leaves all along the main stem, beginning from the first one, will be represented by the following symbols: O, A, A, A, B, B, B, B, C, BC, BCd, C, BC, Cd, Cd, C and so on. Thus, the most developed leaves have 7 lobes, and the central lobes possess teeth. The leaf factor (after Leake) is equivalent, on the average, for the 4th, 5th and 6th leaves to 1·09 and to about 2·00 for the tenth leaf. The central lobe is ovate-oblong (in the centre broader than at the base). The upper and lower sides of the leaf-lamina are densely coated with short hairs; on the lower side, along the veins they are a little longer. The leaf-lamina is green coloured, the knot (junction) of veins is visibly red. There are 1-3 nectaries of a rounded-oblong shape, without hairs inside. The petiole is as long as the lamina; it is comparatively densely covered with long hairs, and is red on the sides exposed to the sun. The stipules are medium sized, lanceolate-crescent shaped, hirsute, with some tinge of redness.

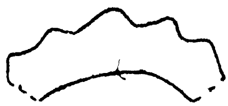
The flower is of medium size, the corolla is half as large again as the involucrum; the petals show a well developed vexillum, pale-yellowish, spotless; only the flowers of the first main sympodial branch and of two accessory branches show a petal spot which is considerably paler than that of the female parent. The anthers and the pollen are yellow. The pollen is abnormal, chiefly semi-spherical in shape, crushed. The stamens are not coloured. The stigma is projecting from out of the stamens, consisting of 4-5 united parts. The calyx is ondulated at the margin, consisting of 5 rounded crenatures; it is sparsely hirsute at the margin, green, with prominent gland dots. The bracts of most of the flowers are separate (with some a slight junction is noticeable); they are 13-15 teethed, the central tooth being ⅓ the length of the main vein; from outside they are covered with hairs, green coloured, and red on the exposed parts. The outer extra-floral nectaries are absent, the inner ones are of a rounded or triangular form with comparatively densely situated hairs. The inner ring of floral nectaries is covered with hairs that are rather densely situated and shorter in comparison with those of the male parent type.



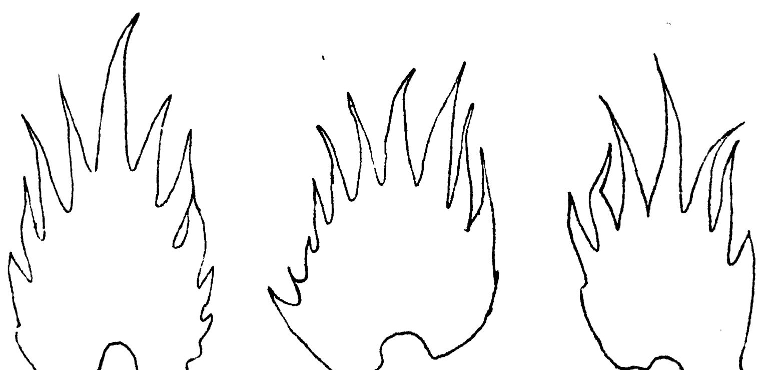
♀ 454 (*G. herbaceum*). a_1, inner view of the petals ; a_2, outer view of the petals ; *b*, calyx (unfolded) ; c_1, bracteoles ; c_2, the junction (growing together) of the bracts.



a



b



c

♂ 221 (*G. hirsutum*) *a*, petals; *b*, calyx; c, bracteoles

The peduncle is green, relatively densely covered with long hairs. The ovaries soon after blooming fall off. The plant is completely sterile. The hybrid (I) that had been left in the ground all the winter under a safe covering appeared in the spring time of 1923 to be considerably injured. For that reason the plant was ratooned. From the buds of the stump new monopodial branches (3 in number) arise—130, 116 and 84 cm. long respectively. Neither in the general development of these branches nor in the character of the various distinguishing features which became apparent as the branches gradually developed was anything extraordinary observed which have distinguished the observations of 1923 from those of the preceding year except in one respect. In the year 1922, the majority of the flowers of the hybrid showed spotless petals; in 1923 all the flowers, which were borne on the above mentioned newly developed branches, showed a dark-crimson spot on the petals, although the tinge of this spot was considerably fainter than that of the female parent. All the flowers appeared to be as sterile as in the first year. During the rather cold winter of 1923-24 both Hybrid I and Hybrid II perished in spite of all the precautions taken.

♀ 154. *G. herbaceum* L.

The main stem and branches. The height of the main stem is about 147 cm. It is coated with a double layer of hairs consisting of very short (about 0·5 mm.) hairs densely situated, and of long hairs (about 2 mm.) that are a little less profuse. The stem is green coloured, with gland dots, and with a slight reddish tinge on the exposed parts. On the lower part of the main stem there are two long monopodia developed from the main buds, and on the upper part of it 20 monopodia of different size, developed from the accessory buds. The main sympodia (27 in number) begin from the sixth node; there are no sympodia developed from the accessory buds. The sympodial branches have comparatively long internodes, the first internode of the sympodium in the middle of the plant equals to 1½-2 internodes of the main stem. The hirsuteness and colour are the same as those of the main stem. On the sympodial branches shortened sympodia are often developed from the accessory buds. The development of the terminal bud into a monopodium can also be noticed.*

The leaves. Symbolically expressing, as has already been done in the case of the hybrid I—the successive row of leaves along the main stem—we obtain the following alternations: O, A, A, B, B, C, C, and so on. Thus, the most developed leaves of the main stem are 7-lobed. The leaf factor (after Leake) equals 0·90, on the average, for the fourth, the fifth and the sixth leaf, while for the tenth it equals to 1·08; to express it in a simpler way (for further comparison) the length of the central lobe is 0·6 of the length of the main vein, the form of the central lobe is

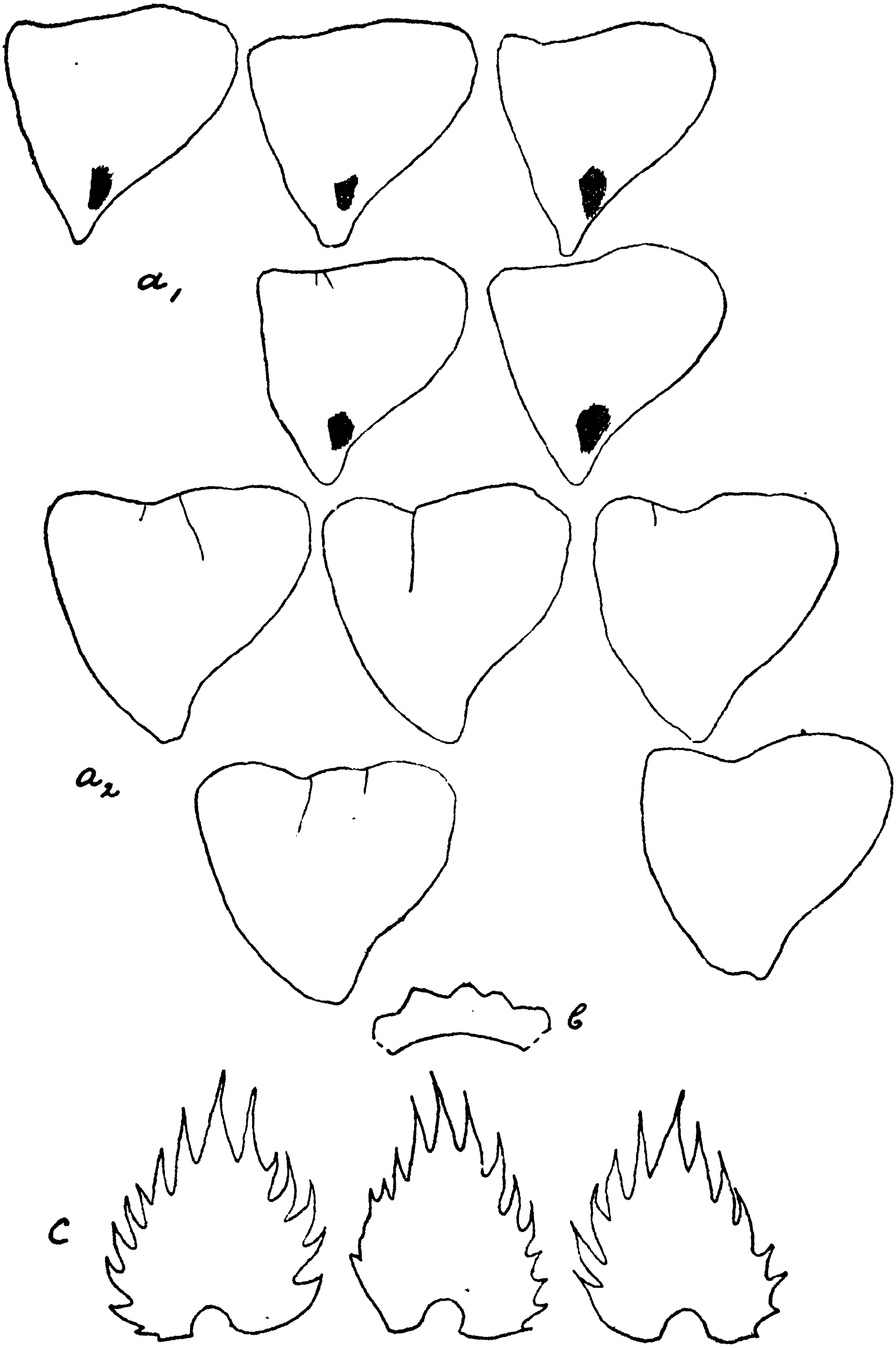
* The degree of the development of the monopodial branches is characteristic only for the year 1922, when the description was made, in connection with that of the first artificial hybrid. The same refers also to the development of the No. 221 mentioned below.

ovate tapering towards the base. The surface of the leaf is often ondulated; the base of the leaf is broadly, but shallow cordate. The leaf-lamina is medium sized, green, covered from its upper side with a dense coating of short hairs, on the lower side the hairs are somewhat denser, and along the veins—somewhat longer. There is one nectary on each leaf, which is small, rounded, horse-shoe shaped. The petiole is as long as the leaf-blade; it is rather densely covered with a double layer of short and long hairs and has a slight reddish tint on the exposed parts. The stipules are lanceolate-crescent shaped, comparatively small, hirsute, green tinged.

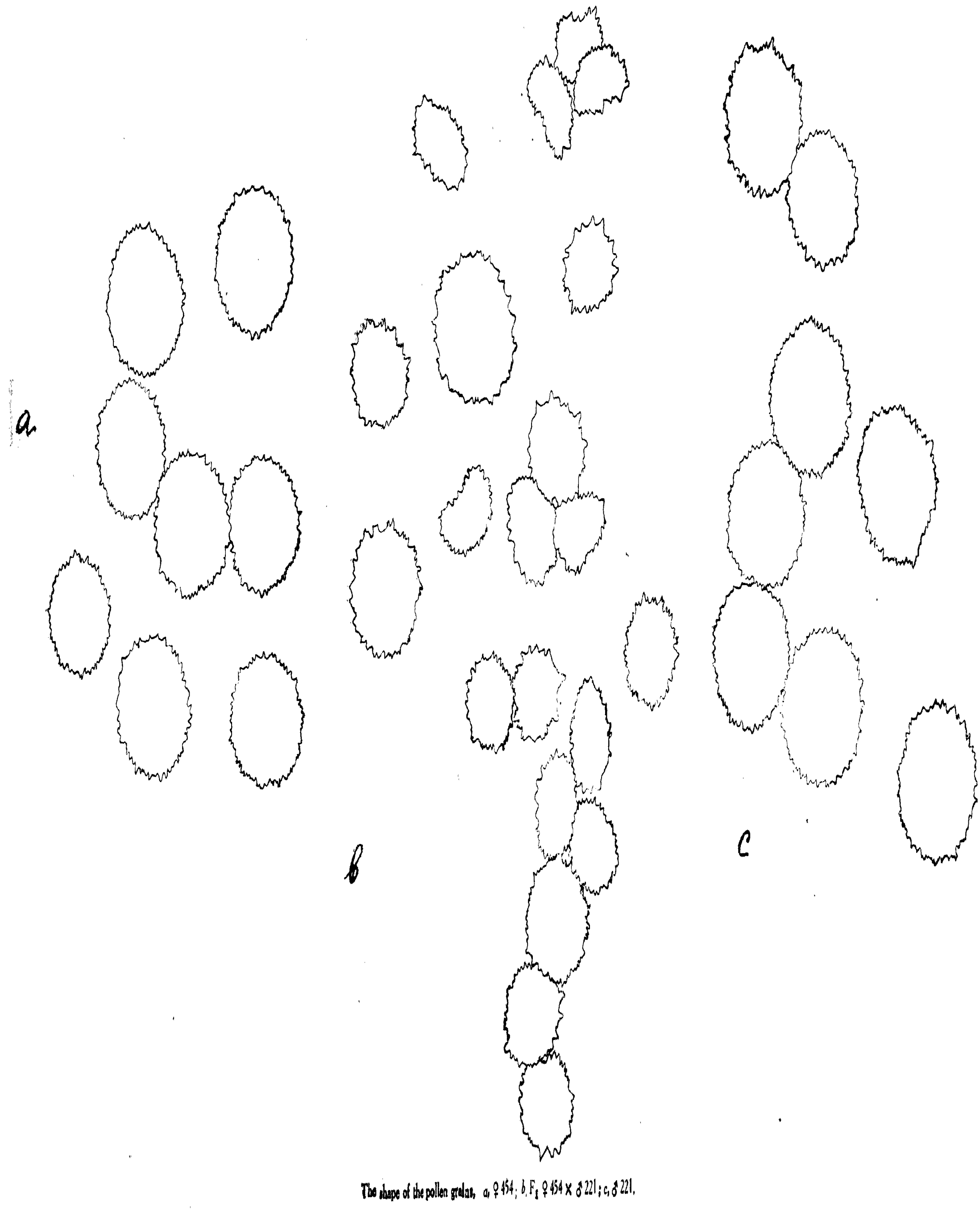
The flower is medium sized, the corolla is one and a half times as large as the involucrum. The petals are of different form—with or without a vexillum, yellow coloured, with a bright-crimson spot inside and a smaller one outside. The anthers and the pollen are yellow. The lower stamens on the staminal column are red. The stigma is short, projecting out of the upper stamens, consisting of 4-5 parts grown together. The calyx is ondulated and hirsute at the margin (having rounded ondulations), green, gland-dotted, the glands are very prominent. The bracts are closely united, dissected into 8-11 teeth (the central tooth is one-third the length of the central vein); on the outside the bracts are densely covered with short hairs, that partly reach the interior side; they are green coloured. The outer extra floral nectaries are absent; the inner ones are large, triangular, densely covered with short hairs. The inner ring of floral nectaries has no hairs at all. The peduncle is medium sized, green, hirsute—the hairs are of two types: the first short, densely situated, and the second long, sparsely situated; the peduncle of a fruit is reddish on the exposed parts. The boll is spheroidal, with breadth equalling or slightly exceeding the length, green, with a smooth surface, 4-5 locular, hanging when ripened. The dehiscence is not considerable but the valves open almost entirely. The lint is white, distributed all over the whole seed, and short. The seed is of medium size, densely coated with a pale-greenish (white at fading) closely adherent fuzz.

♂ 221. *G. hirsutum* L. *var. laciniatum* Zaitz.

The main stem and branches. The height of the main stem is about 140 cm. It is covered with a single layer of long hairs of a medium density. The colour of the stem on the exposed parts is dark-red. There are two monopodia on the stem below, developed from the main buds, and one of them is highly developed; above them there are 6 monopodia of different length arising from the accessory buds. The main sympodia (26 in number) begin from the 4th node, the sympodia developed from the accessory buds (13 in number) begin from the 11th node and are faintly developed. The main sympodial branches re long with long internodes, the first internode of the sympodium in the middle of the plant equals to two internodes of the main stem. The hirsuteness and colour of the sympodial branches are the

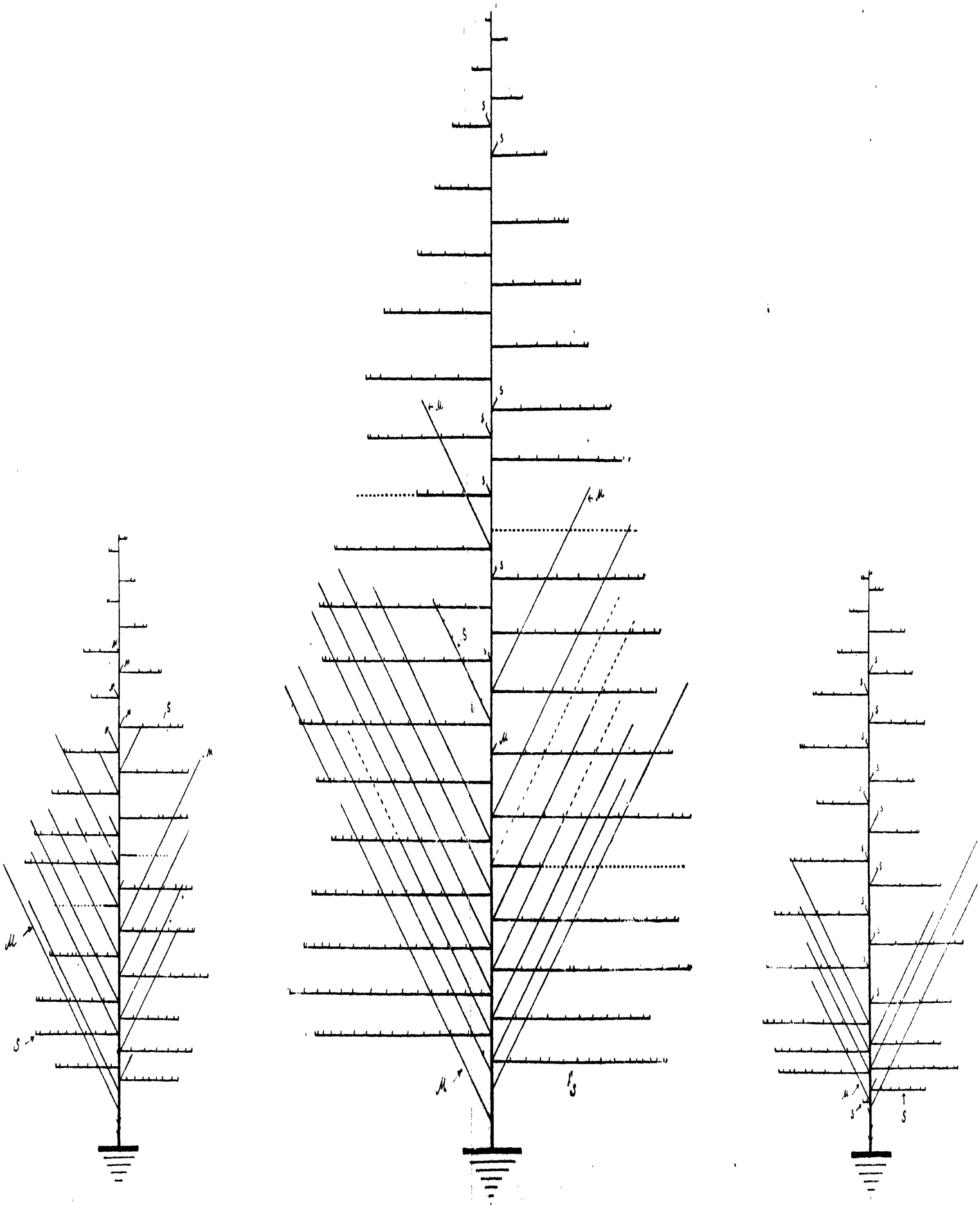


F_1 ♀ 454 × ♂ 221. a_1, spotted petals (a part of hybrid flowers); a_2, spotless petals (most of the hybrid flowers); b, calyx; c, bracteoles.



The shape of the pollen grains, *a*, ♀ 454; *b*, F_1 ♀ 454 × ♂ 221; c, ♂ 221.

PLATE XXI.



Diagrams of the hybrid plant ♀ 454 × ♂ 221 in the middle, of the female parent on the left, and of the male parent on the right. The horizontal lines are the sympodia with indications of the places of the flowers; the inclined lines are the monopodia (their branching is not indicated); by the letter s are designated the accessory sympodia; the dotted lines show the injured branches.

(*a*) At an early stage.

(*b*) At the end of vegetation.

Hybrid I, ♀ 454 (*G. herbaceum*) × ♂ 221 (*G. hirsutum*).

PLATE XXIII.

Hybrid F_1 ♀ 454 × ♂ 221 in the middle ; the female parent on the left ; the male parent on the right.

same as those of the main stem. In rare cases the sympodia develop other shortened sympodia from the accessory buds.

The leaves. The expression of the successive row of leaves, using the same symbols as above, beginning from the first leaf has the following appearance: O, OA, OA, OA, A, A, A, B, Bd, Bd and so on. The most developed leaves of the main stem are five lobed. The leaf factor (after Leake) equals 1·42, on the average, for the 4th, 5th and 6th leaf and 3·54 for the 10th. The length of the central lobe equals the whole length of the central vein; this lobe often has teeth at the margin. The surface of the leaf is not ondulated; the base of the leaf is broadly but shallow cordate. The leaf blade is medium sized, green; it is covered with short hairs from above; from below the hairs are denser situated. There are 1-3 nectaries on the leaf, of a medium size, horse-shoe-shaped. The petiole is as long as the leaf-lamina or somewhat shorter; it is covered with long hairs, and red on the exposed parts. The stipules are lanceolate crescent shaped, rather small, covered with long hairs and red on the exposed parts.

The flower is medium sized; the corolla being one and a half times the size of the involucrum, the petals possess a well developed vexillum, they are pale-cream coloured, spotless. The anthers and the pollen are cream-coloured. The stamens are not tinged. The stigma is short, projecting out of the upper stamens, consisting of 4-5 parts grown together. The calyx is crenulated along the margins with five triangular crenatures, hirsute, green with very prominent gland dots. The bracts are free, dissected into 12-14 long teeth; the central tooth is as long as a half of the main nerve; outside they are hirsute, green with a reddish tinge on the exposed parts. The outer extra-floral nectaries are roundish-oblong, comparatively small, with long hairs; there are no interior ones or they are hardly noticeable. The inner ring of floral nectaries possesses hairs. The peduncle is of medium size, green, reddish on the exposed parts, and covered with long hairs. The boll is egg-shaped; it is rather longer than broader, green, with a smooth surface, having 4-5 locules, on ripening it does not droop. The dehiscence is considerable. The lint is white, distributed all over the whole seed and medium-short. The seed is medium sized, with a greenish (grey after fading) fuzz closely adherent to the seed.

II. The artificial hybrid ♀ 455 ι (G. herbaceum L.) × ♂ 59 (G. hirsutum L. var. calvatum Zaitz.).

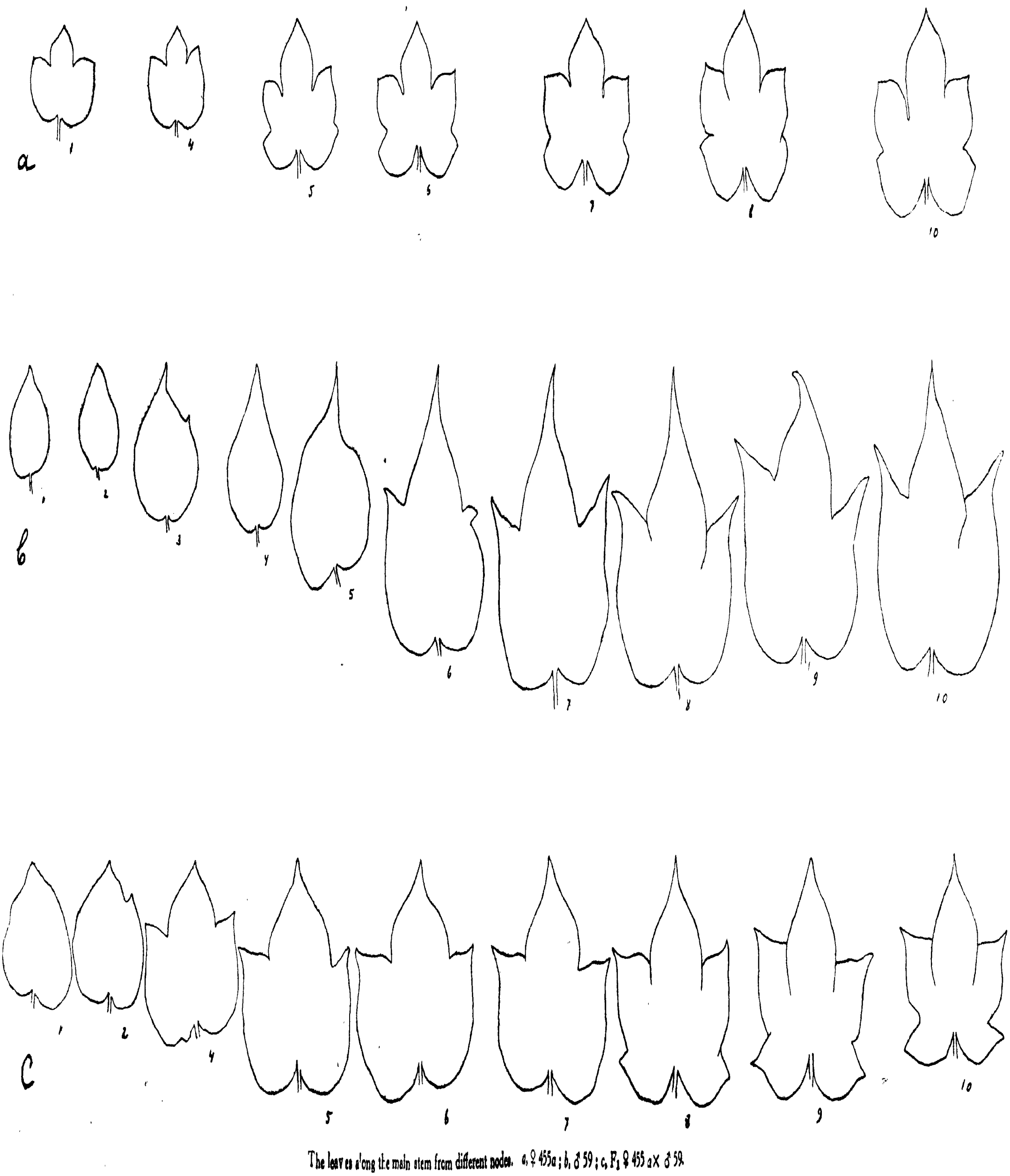
The seedlings. The cotyledons seem to occupy a ι intermediate position in respect o the prominentness of the glands. The hypocotyl is glabrous, but has hair-shaped protuberances like 59.

The main stem and branches. The height of the main stem is 163 cm.; it is covered with a single layer of medium short hairs (about 0·5-0·7 mm. long) comparatively densely situated. The colour of the stem is relatively bright-red on the exposed parts; in respect to the colour of the stem the hybrid seems to occupy an inter-

mediate position, but it is somewhat closer to the female parent type. There are seven monopodial branches, two lower branches arise from the main buds and five others from the accessory buds (Pl. XXVII); the monopodial branches are of medium development in comparison with that of the main stem. The first sympodial branch developed from a main bud arises from the 5th node; the sympodial branches developed from accessory buds begin from the 16th node. The sympodial branches arisen from the main buds are long, with rather long internodes; the accessory sympodia are shortened and bear only one flower (Pl. XXVII). The general development of the whole plant shows heterosis, though in a slighter degree than that of the hybrid I. The pubescence and colour of the sympodial branches are similar to those of the main stem.

The leaves. The successive row of leaves all along the main stem, beginning from the first leaf, may be symbolically represented as follows: O, OA, A, A, A, A, A, B, B, B, B, C, B, B, and so on. The central lobe of the first leaves is roundish triangular, while that of following more developed leaves is ovate, distinctly tapering towards the base, like the central lobe of the leaves of the male parent plant. The sympodial leaves, as is always observed, have partly a smaller number of lobes (3-4, rarely 5) with shallower indentations; their central lobe is ovate. The hairs on the upper side of the leaves are short; in respect to their length they occupy an intermediate position between ♀ 455a and ♂ 59. On their lower side the type of pubescence is the same, but the hairs are denser. The colour of the leaf is green; the veins and the "knot" have a very faint anthocyanin tinge. All the leaves, except the lowest ones, have three nectaries; the leaves of the sympodial branches have only one or two nectaries. The petiole is almost as long as the leaf-lamina; it is covered with short hairs, but there are also a few long hairs very sparsely situated. The petiole is bright-red coloured on the exposed parts.

The flower is medium-sized; the petals have a well-developed vexillum and are bright yellow in colour with a broad crimson spot at the base inside, and with a smaller spot outside. The spot is present on all the flowers of the plant. The anthers and pollen are yellow, but their colour is somewhat paler than that of ♀455a; the pollen is spherical and semi-spherical, poorly developed and possesses thorns. The stamens are comparatively short, untinged, excepting the lower ones which are crimson coloured. The stigma is of a medium length, considerably projecting out of the upper stamens. The calyx is green, with five ununiform crenatures; at the margins of the crenatures are short hairs. The bracts are free, dissected into 9 rather long teeth, the central of which equals to ½ of the main nerve. The outer surface of the stipules and the margins of the crenatures are covered with hairs of medium size. The outer extra-floral nectaries are absent, th inner ones are oblong rounded with medium short hairs. The inner ring of floral nectaries has no hairs. The ovaries (4-locular) fall off some days after blooming. The plant is completely sterile.

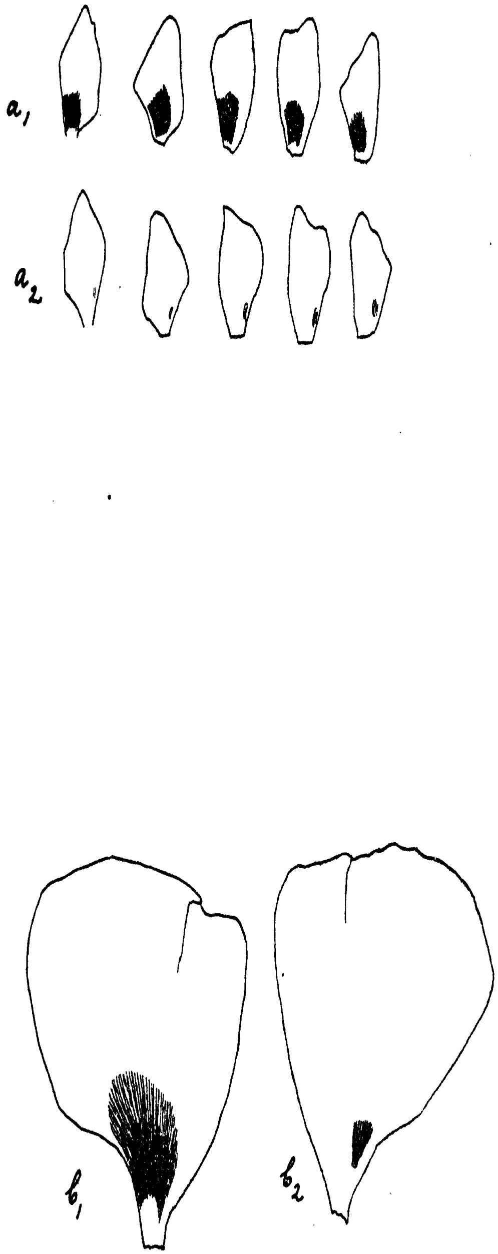


The leaves along the main stem from different nodes. *a*, ♀ 455*a* ; *b*, ♂ 59 ; *c*, F_1 ♀ 455 *a* × ♂ 59.

PLATE XXV.

The bracteoles. a, ♀ 455a; b, ♂ 59; c, F_1 ♀ 455a × ♂ 59 (at left is shown the junction).

PLATE XXVI



The petals. a_1, ♀ 455a (from the inner side); a_2, ♀ 455a (from the outer side); b_1, ♀ 455a × ♂ 59 (from the inner side) b_2, ♀ 455a × ♂ 59 (from the outer side).

♀ *455a. G. herbaceum* L.

The seedlings. The cotyledons are glabrous with slightly marked glands, which are sometimes more sparsely situated than those of the Upland No. [illegible] (*G. hirsutum* L. var. *calvatum* Zaitz.). The hypocotyl is covered with distinctly noticeable hairs, rather numerous and short.

The main stem and branches. The plant is short; it is covered with a double layer of hairs, the upper layer consists of long hairs (about 2 mm.) very sparsely situated, while the lower layer consists of very short ones (about 0·2 mm.) very densely situated. The colour of the stem is red on the exposed parts and green on the opposite ones. There are either no monopodial branches at all at the base of the stem, or they are poorly developed (one to three in number). The first main sympodial branch arises from the 5th node; above it, beginning from the 6th node, are situated shorter sympodia, developed from the accessory buds. The sympodial branches are rather long with relatively long internodes; the first internode of the sympodium in the middle of the plant equals two internodes of the main stem. The accessory buds of the sympodia rather frequently develop shortened sympodia, and sometimes even monopodia; in some very rare cases the development of the terminal (flower) bud into a monopodium may be observed. In respect to the hirsuteness and colour the sympodial branches are similar to the main stem.

The leaves. The successive row of leaves all along the main stem beginning from the first leaf, may be symbolically represented as follows: A, A, A, A, B, B, and so on; only at the 14th and 18th node the leaves are 7-lobed-C. The form of the central lobe of the leaf is ovate, it is short, its length equals to ½ of the main nerve; it is more narrow at the base than in the middle and very shortly pointed at the top. The base of the leaf is broadly, but shallow cordate. The petiole is as long as the leaf-blade, and is covered with a double layer of hairs, namely, dense short hairs and sparsely situated long ones. It is crimson-coloured on the exposed parts and green on the opposite. The hairs of the upper side of the leaf are very short, densely situated; on its lower side they are much denser, and along the veins they are somewhat longer. The leaf is green coloured, in the nerve-knot (and partly along the veins) sometimes a very slight anthocyanin tinge may be observed. There are 1-2 nectaries on each leaf, which are small and horse-shoe-shaped.

The flower is small; the corolla is one and a half times the size of the involucrum; the petals are not uniform but may be with and without a vexillum, are comparatively small, yellow, with a large crimson spot at the base inside and a smaller one outside. The anthers and the pollen are yellow; the stamens are colourless, but the lower ones have a crimson tinge. The stigma is short, almost sinking down amidst the upper stamens. The calyx is green, ondulated at the margin, with five unequal ondulations.

There are very sparse short hairs on its margins. The bracts are closely united, dissected into 9 teeth; the central tooth is one-third the length of the main vein; on the outside and along the margins they are covered with short hairs. The outer

extra-floral nectaries are absent, the inner ones are rather large, triangular in form and densely coated with minute hairs. The inner ring of floral nectaries has no hairs. The boll is short, egg-shaped, small (length about 25 mm. and diameter 20 mm.), 3-4 locular, green, smooth. The valves are perfectly dehiscing. The seed is small, with white lint distributed all over its whole surface, and with grayish closely adherent fuzz coating the whole seed.

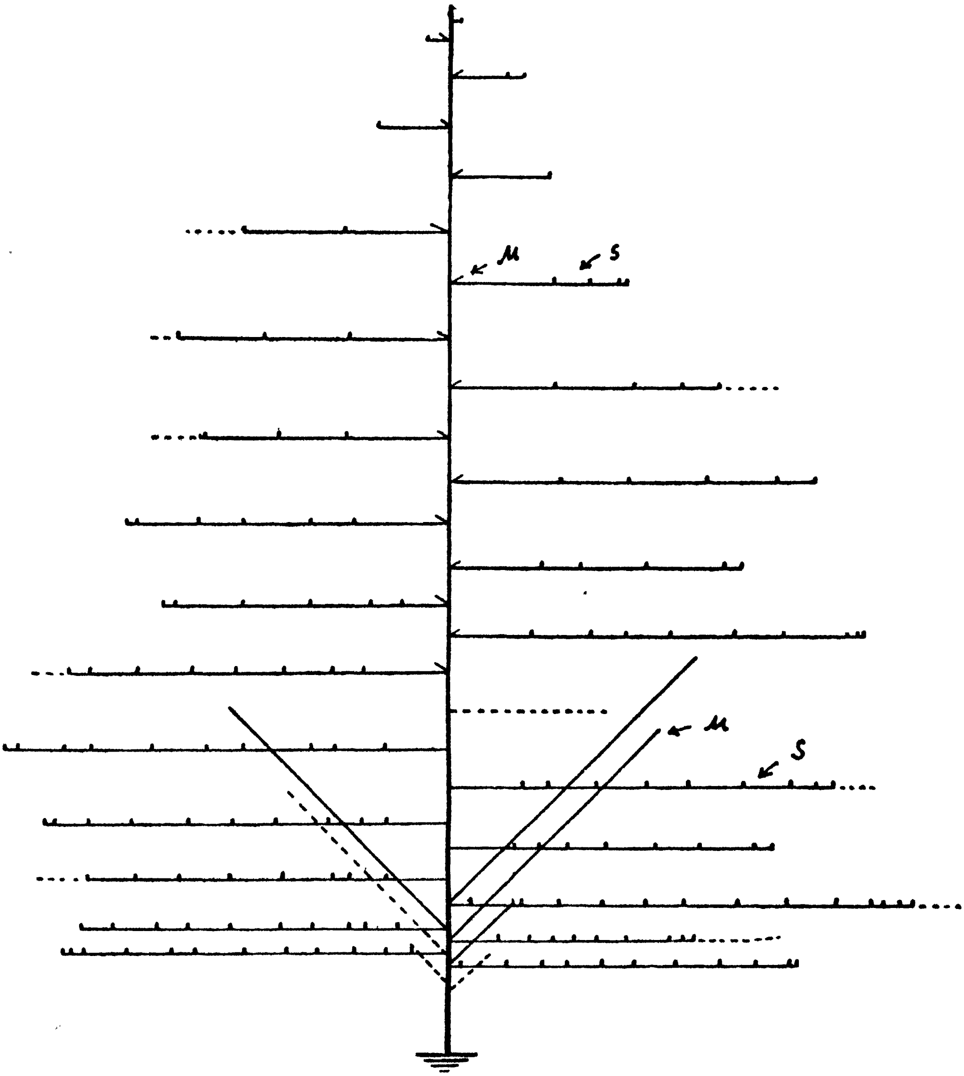
♂ 59. *G. hirsutum* L. *var. calvatum* Zaitz.

The seedling. The cotyledons are glabrous with prominent glands, that are rather numerous. The hypocotyl is also glabrous, only on its upper part a few hair-like protuberances are present.

The main stem and branches. The plant is of medium size ; it is covered with a single layer of hairs (about 2 mm. long) comparatively densely situated. The colour of the stem is green, but the exposed parts have a very pronounced dark-red anthocyanin tinge. There are about 3-5 monopodial branches in the lower part of the stem, which are of medium development. The first main sympodial branch arises from the 5th or 6th node ; the accessory shortened sympodia can be observed beginning from the fourteenth node. The main sympodia are long, with comparatively long internodes ; the first internode of the sympodium in the middle of the plant equals to two internodes of the main stem. On the sympodial branches no accessory branching was observed. The hirsuteness and colour of the sympodial branches are the same as those of the main stem.

The leaves. The successive row of leaves, beginning from the first one, is represented by the following symbols : O, O, OA, O, O, A, A, A, A, A, A, A, A, B, B, and so on. The central lobe is triangular in shape, it is broader at the base than in the middle, gradually tapering towards the top. The base of the leaf is medium cordate. The hairs on the upper side of the leaf are short, but still somewhat longer than those of ♀ 455a and are of a medium density, on the lower side the hairs are still denser. The leaf is green, the veins and especially the " knot " have a bright anthocyanin tinge. There are 1 to 3 nectaries on each leaf, they are rather small, and of a roundish form. The petiole is as long as the leaf-blade, it is covered with long hairs and dark-red tinged on the exposed parts.

The flower is of medium size ; the corolla is one and a half times the size of the involucrum ; the petals are all uniform possessing a well developed vexillum, they are pale-yellow tinged, without spots. The anthers and the pollen are pale-cream coloured. The stigma hardly protrudes from amongst the stamens ; the calyx is green with five triangular crenatures, and is covered with hairs on the margins (near the top of the crenatures). The bracts are free and possess 9 rather long teeth ; the central tooth is half the length of the central vein ; on the outside and at the margins the teeth are covered with medium-sized hairs. The outer extra-floral nectaries are relatively small, of a rounded or oblong shape and are covered with



The diagram of the hybrid plant F_1 ♀ 455*a* × ♂ 59. The horizontal lines are the sympodia; the inclined ones, the monopodia; the dotted lines show the injured branches.

comparatively small hairs. The inner extra-floral nectaries are absent. The inner ring of floral nectaries is hirsute.

The boll is egg-shaped, medium sized, about 40 mm. long and about 30 mm. in diameter, 4-5 locular, green, with a smooth surface. The opening of the valves is perfect with a considerable diver ence. The seed is medium-sized with white lint of a medium length distributed all over the whole seed, and with a greenish (grayish at fading) fuzz, which in most cases covers only the narrow end of the seed near the micropyle. The sides of the seed and the khalaza are mostly glabrous.

In the Station field collection of 1924 in a family of the variety No. 289 (*G. herbaceum* L.) a natural hybrid with *G. hirsutum* was discovered. The preceding year, this variety was grown in the neighbourhood of the standard variety *G. hirsutum* No. 182. Probably, natural crossing with it took place. A description of the natural hybrid which differed in particular from the rest of the family of No. 289 by its sterility is given below. Descriptions of the female parent and of the suspected male parent are also given.

♀ 289. *G. herbaceum* L.

The main stem and branches. The main stem is 85 cm. high and 0·6-0·8 cm. thick in the lower part; the length of the internode in the middle of the stem is about 3½ cm. The plant is covered with a double layer of hairs: the upper layer consists of long hairs of a medium density, the lower one—of short very densely situated hairs. On the exposed parts, the stem has an anthocyanin colour, while all the rest of it is green, with minute, comparatively densely situated black, prominent, gland dots. On the stem below there are two very strong monopodial branches, developed from the main buds; further, there are six monopodia of medium development, arisen from the accessory buds. The first sympodium arises from the fifth node; there are in all 24 sympodia developed from the main buds. The number of sympodia arising from the necessary buds is 5, the first of them is developed from the 18th node. The sympodia are medium-sized, round in cross-section; the average length of the first internode of the s mpodium n the middle of the plant equals 1½ internodes of the main stem (about 5 cm.). In respect to pubescence and colour the sympodia are similar to the main stem. An accessory branching of the sympodial branches may be observed, and in the result of it are more frequently developed monopodia, and less frequently sympodia; in some cases the metamorphosis of the terminal bud is observed when on a sympodium instead of a flower arises a monopodium. In cases when a considerable accessory branching takes place, the whole plant obtains a strongly entangled bushy appearance, especially as the sympodia consist of non-uniform stragg ing internodes.

The leaves. Along the main stem the most developed leaves are 7-lobed (in the middle of the stem) with an ovate central lobe, tapering to the base, which equals ⅘ of the central vein. The surface of the leaf is ondulated especially at the

base of the veins. The base of the leaf is cordature narrow and deep (about $1\frac{1}{2}$ cm.). The leaf-blade is long and broad, respectively $7\frac{1}{2} \times 10$ cm. From outside, the leaves are densely coated with short hairs; from below, along the veins, the hairs are somewhat longer. The leaf-blade and the veins are green coloured, the "nerve-knot" has a reddish tinge at his base. There is more frequently one nectary on each leaf, rarely 2. The nectaries are small and of a rounded form. The petiole is somewhat shorter than the leaf-lamina; it is covered with two layers of hairs and has an anthocyanin tinge on the exposed parts. The stipules are lanceolate-crescent shaped ($16 \times 2\frac{1}{2}$ mm.), densely covered with short hairs, green, sometimes with a pale-anthocyanin tinge.

The flower is comparatively small; the petals hardly exceeding the involucrum, not uniform (with and without a vexillum), bright-yellow coloured, with a very pronounced bright-crimson spot at the base of their inner side and with a smaller spot on their outer side. The anthers and the pollen are bright-yellow. The lower stamens are reddish coloured. The stigma projects out of the stamens, consisting of 3-4 closely united parts. The calyx is ondulated at the margin, having sparse hairs; bright-yellow coloured, with prominent gland dots. The bracts are united at the base (5 mm.) and are dissected into 9 triangular teeth, tapering towards the base; the central tooth is equal to $\frac{1}{4}$ of the main vein; from outside their surface is densely covered with short hairs which are often observed on the inner side also. The bracts are green coloured, red on the exposed parts. There are no outer extra-floral nectaries, the inner ones are medium sized ($2 \times 2 \cdot 2$ mm.), triangular shaped, and are densely covered with very minute hairs. The inner ring of the floral nectaries has no hairs. The peduncle is short, with dense short hairs, and long sparsely situated ones, green coloured, reddish on the exposed parts. The boll is spherical, it is as long as broad (28×29 mm.); in most cases it is 3-5 locular, hanging when ripened; it has a medium dehiscence. (The edges of the valves are rather widely diverging.) The lint is brown, distributed all over the whole seed, short (less than 25 mm.). The seed is medium sized, covered all over its surface with a brown fuzz partly closely adherent to the seed.

♂ 182. *G. hirsutum* L.

The main stem and branches. The main stem is about 125 cm. high; its thickness near the base is 1·3 cm., in the middle 0·8 cm.; the length of the internode in the middle of the plant is about 8 cm. It is covered with a single layer of long, medium dense hairs which fall off with growth. The stem is dark-red on the exposed parts and green on the opposite ones, with a considerable number of gland dots. There is one medium strong monopodium, developed from a main bud, and another, more developed one, arisen from an accessory bud. The first sympodium (developed from a main bud) arises from the 5th node; there are in all 19 main sympodia; the first accessory sympodium arises from the 9th node, there are in

all 9 accessory sympodia. The sympodia have elongated internodes; the first internode, on the average, equals to two internodes of the main stem; in the middle of the plant the length of the first internodes is 15 cm. approximately. In respect to the pubescence and colour the sympodial branches are similar to the main stem. The accessory buds of the sympodial branches develop often shortened sympodia with a single flower, and that is the reason why some nodes bear sometimes two bolls.

The leaves. The most developed leaves on the main stem are 5-lobed; the central lobe is ovate-triangular, with a pointed and stretched out tip. The length of the central lobe equals to $\frac{1}{2}$ of the length of the main nerve of the leaf. The surface of the leaf is smooth, not ondulated. The base of the leaf is deeply (about 2 cm.) and narrow cordate. The dimensions of the leaf-blade are $10\frac{1}{2} \times 15$ cm. The leaves are covered on their upper side with medium sized hairs, densely situated; their lower side is more profusely coated, along the nerves the hairs are longer. There are mostly 3 nectaries on the leaves of the main stem, medium sized, of a roundish oblong form. The petiole is as long as the leaf-blade; it is covered with long hairs and has an anthocyanin tinge on the exposed parts. The bracts are broad, lanceolate-crescent shaped (13×4 mm.), slightly hirsute, with a reddish tinge.

The flower is medium sized; the petals exceeding the involucrum, with a well developed small vexillum, pale-yellowish (cream-coloured), spotless. The anthers and the pollen are pale-yellowish (cream-coloured). The stamens are also pale-yellowish. The stigma projects from the stamens and consists of 4-5 closely united parts. The calyx is green, with very prominent gland, with 5 crenatures at the margin; the crenatures are triangular, hirsute at the edge. The bracts are free or very slightly united (about 2 mm.), dissected into 13 long, narrow teeth; the central tooth is half the length of the main vein; on the outside the bracts ar cover-ed with hairs; they are green, with some tinge of redness on the exposed parts. The outer extra-floral nectaries are rounded (about 1-$1\frac{1}{2}$ mm. in diameter) with hairs scattered here and there: there are no inner extra-floral nectaries. The inner ring of floral nectaries has a distinctly visible band of hairs. The peduncle is short, hirsute with medium long hairs, green with some reddish tinge. The boll is egg-shaped, about 42 mm. long and 33 mm. in diameter, green, with an almost smooth surface, 4-5 locular, not drooping when ripe, perfectly dehiscing. The lint is white, distributed all over the whole seed, and about 25 mm. in length. The seed is medium-sized and covered all over its whole surface with greenish (grayish at fading) fuzz.

(*To be continued*)

THE RELATIONSHIP OF CANAL IRRIGATION AND MALARIA.*

BY

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IT is widely believed that an increased incidence of malaria is a regrettable but inevitable accompaniment of canal irrigation, and many generations of administrators, engineers and sanitarians in the Punjab have accepted the view that malaria represents the price that must be paid for freedom from famine and for the material prosperity arising out of an assured and abundant food-supply.

The benefits conferred by canal irrigation are indeed so great and of such far-reaching importance that many are prepared to justify or at least to condone the lesser evil of malaria, but it is nevertheless an assumption based upon vague impressions and preconceived notions that the great Punjab canals are responsible for any appreciable increase in the incidence of malaria in this province. Opinions on the subject have varied in a remarkable manner. To many the syllogism "canal water means mosquitoes, mosquitoes mean malaria, therefore canal irrigation means malaria" has been regarded as entirely convincing. Some, however, have appealed to statistics and have quoted figures purporting to show that the introduction of canal irrigation has been followed by marked increase of "fever" mortality; others, such as that able statistician, Mr. S. M. Jacob, I.C.S. (Retired), on the other hand by an appeal to these same statistics, have reached diametrically opposite conclusions.[1]

It is clearly inexpedient that a question of this importance should remain permanently in an equivocal position, and it is peculiarly fitting and even necessary that an effort should be made in the Punjab, whose prosperity is so profoundly dependent upon canal irrigation, to elucidate the precise influence of canal irrigation upon the state of the public health. It indeed seems proper, be the consequences what they may, that the facts should at least be placed upon record. A mass of facts have accordingly been collected in the course of the investigation of malaria in the Punjab during the past 13 years, and, in view of the appointment of the Royal Commission on Agriculture, the time is opportune for an analysis of these

* Paper read at the Indian Science Congress, Lahore, 1927.

[1] *Punjab Census Report*, 1921, p. 62.

facts and for placing on record the general conclusions which they appear to justify.

A more detailed examination and a fuller statement is under preparation, but it is thought that the facts recorded in this note (which it may be remarked incidentally do not bear out the gloomy views widely held upon the subject) suffice to establish certain outstanding facts regarding the influence upon malaria of the great canal system maintained by the Punjab Government.

In any consideration of the subject the first point it is necessary to emphasize is the fact that malaria exhibits itself in two forms: (1) as great widespread epidemics attended by high mortality, and (2) as endemic malaria which ordinarily causes little or no direct mortality but is associated with more or less marked ill-health (anæmia, enlargement of the spleen) and relatively low fecundity.

The second point arises partly out of the first. It is necessary to realize that the "fever" mortality statistics throw little or no light upon the prevalence of *endemic* malaria, but they are mainly indicative of the incidence and severity of *epidemics* of malaria.

Another point of fundamental importance is the fact that the "fever" mortality figures represent the sum of three components:—

(1) The mortality occasioned by epidemics of malaria (the epidemic mortality).
(2) The non-epidemic mortality—75 per cent. or more of which is *not* due to malaria at all.
(3) An uncertain proportion (usually much under 25 per cent.) of the non-epidemic "fever" mortality which *may* be referable to endemic malaria.

In view of these circumstances the only feasible method of approaching the problem under consideration is the determination *separately* of the influence exercised by canal irrigation upon endemic and epidemic malaria respectively.

The characteristics of these two manifestations of malaria—of which epidemic malaria is by far the more important—are highly distinctive, since epidemics of malaria are associated with a high death-rate during short periods only and a remarkable freedom from malaria mortality during inter-epidemic periods. On the other hand, as already stated, endemic malaria causes a small but constant death-rate of not accurately determinable proportions, but is associated with a constantly high spleen-rate and a relatively low birth-rate.

Nevertheless, although endemic malaria is not responsible for many deaths, it is important to recognize that it may exercise in the long run a more harmful effect upon the public health than even the most severe epidemic.

The first question for consideration is, therefore, what is the relationship existing between canal irrigation and epidemic malaria as indicated by relatively high "fever" mortality?

As long ago as 1911 S. R. Christophers[1] showed that the great epidemic of malaria in 1908 exhibited no relation to the tract under canal irrigation; it was, indeed, clear that irrigated tracts often escaped, whilst many unirrigated districts were most severely implicated.

A study of the history of malaria in the Punjab during the past 56 years shows that this feature has been consistently displayed by epidemic malaria, but this absence of relationship between epidemic areas and canal irrigated tracts is now less obvious than formerly because many of the unirrigated tracts in which epidemics of malaria have been notoriously severe have recently been brought under canal irrigation. Montgomery and Gujrat Districts, for example, which have only recently been irrigated, have been the scene of some of the most severe epidemics of malaria on record. Nevertheless, it is still clear to anyone acquainted with the history of epidemic malaria in the Punjab and its distribution in space that *canal irrigation plays no appreciable part in determining the incidence and severity of these epidemics*. In these circumstances it would be expected, since the "fever" mortality over a series of years largely reflects the mortality occasioned by epidemic malaria, that statistical analysis would fail to show a "significant" degree of correlation between the acreage under canal irrigation and "fever" mortality over a decade. And this is the conclusion reached by Mr. Jacob, which, in so far as epidemic malaria is concerned, may be accepted as an accurate induction. On the other hand, it is now easy to explain the contrary conclusions reached by other statisticians, since if a decade be taken in which an irrigated tract has been severely involved in an epidemic, a high degree of correlation might well be found to exist between "fever" mortality and canal irrigation and it might consequently be inferred that canal irrigation was responsible for the high "fever" mortality. It is thus clear that statistical analysis, unless they are based upon a knowledge of the epidemiology and endemiology of malaria, are apt to lead to conclusions which may be statistically correct but are nevertheless biologically erroneous.

Mr. Jacob's induction would thus be wholly fallacious if it were applied to endemic malaria, since, for reasons already given, a great increase of endemic malaria (as the result of canal irrigation or of any other cause) might be associated with little or no appreciable increase of "fever" mortality.

In order to determine the effect of canal irrigation upon endemic malaria, it is necessary to examine the relationship existing between canal irrigation and the various factors indicative of this form of the disease. These may be briefly summarized as follows :—

(1) A relatively high "fever" death-rate during non-epidemic periods.

(2) A relatively high and constant spleen-rate.

(3) A relatively low birth-rate at all times.

Investigation shows, speaking generally, that the non-epidemic "fever" mortality (which is only partly attributable to malaria) is a fairly constant figure

[1] Malaria in the Punjab. *Sci Mem of Officers of the Medical and Sanitary Departments of the Government of India*, N. S., No. 46.

both in irrigated and non-irrigated tracts, and it does not therefore seem probable that canal irrigation can be an important factor in determining its height. This type of "fever" mortality, speaking generally, is however relatively high in the sub-montane tract where, it may be remarked, canal irrigation (by means of perennial canals) is not in vogue.

As regards the spleen-rate, it is now known, as the result of the bi-annual spleen census carried out in the Punjab during the past 13 years, that the extremely high spleen-rates prevailing immediately after an epidemic decline uniformly and rapidly both in irrigated and in non-irrigated tracts. It is therefore permissible to assume that canal irrigation does not ordinarily interfere with this spontaneous decline of the spleen-rate, and that, in consequence, canal irrigation does not retard recovery from the effects of an epidemic. It is also clear that in the *unirrigated* sub-montane tract (more especially the district of Kangra), the spleen-rate remains constantly at a higher level than in the *irrigated* plains of the Punjab.

As regards the birth-rate, in spite of epidemics (which cause a sharp decline in the birth-rate in the year succeeding their occurrence) the birth-rate of the Punjab (40·0 per mille approximately) is invariably one of the highest in India. A study of the mean birth-rate during the quinquennium 1920-1924 in irrigated and unirrigated districts also shows that the average birth-rate of the six most widely irrigated districts in 1918-1919 was 42·1 per mille as compared with a mean provincial birth-rate of 40·9 per mille during the corresponding period.

It may perhaps not possess much significance but it is a fact that the two districts with the largest number of acres of irrigated land per square mile (Lyallpur and Amritsar) during the year 1918-1919 showed a higher mean birth-rate (48·2 and 47·1 per mille respectively) than the corresponding figure of any other district of the province during this quinquennium. It is also noteworthy that in certain parts of the sub-montane tract (Kangra District) where endemic malaria is more prevalent than elsewhere, the birth-rate is constantly lower than it is in irrigated tracts in the plains. Other factors, such as age composition of the population, must no doubt be held to be partly responsible for these variations of the birth-rate, but it is at least permissible to infer that no depreciation of fecundity, as the result of endemic malaria, can be detected in irrigated tracts. So much for the general relationship existing between canal irrigation and endemic and epidemic malaria respectively. The general conclusion reached, as the result of this brief review of the situation, is that, speaking generally, canal irrigation cannot properly be held to play a rôle of appreciable importance in determining the incidence and severity of either endemic or epidemic malaria in the Punjab. This conclusion, it is important to note, is however not of universal application; many investigations have indeed shown that where canal irrigation gives rise to water-logging, a grave degree of endemic malaria, associated with a constantly high spleen-rate, a low birth-rate and, finally, with depopulation, is an almost inevitable result. It is only necessary to recall the historic instance of the old

Western Jumna Canal, and, in modern times, the serious degree of endemic malaria that has occurred in certain areas in Sialkot, Gujranwala and other districts as the indirect result of water-logging caused by seepage from large canals. These areas are however small in extent and for the most part limited to narrow strips in the immediate vicinity of large canals or of their main branches. Another instance of the harmful effect of canal irrigation, although less serious in degree, is illustrated at Amritsar city,[1] where excessive irrigation of gardens or orchards in and near the city was responsible for a relatively high degree of endemic malaria amongst those living in the immediate vicinity.

This brief review of the situation permits of certain definite conclusions which may be summarized as follows :—

(1) Canal irrigation is not a factor of any importance in determining the incidence or severity of epidemics of malaria.

(2) It can be asserted with equal confidence that *open field irrigation* has not been responsible for any appreciable general increase of endemic malaria.

(3) As a general statement it may safely be concluded that the salubrity (so far as malaria is concerned) of irrigated tracts compares favourably with unirrigated areas.

(4) As a partial exception to the general rule it is certain that wherever canal irrigation gives rise to water-logging a vicious circle is set up in which endemic malaria leads to bad health, bad health to economic stress and economic stress to further privation and more sickness, and, finally, as the combined result of a high death-rate, a low birth-rate and emigration, to the depopulation of the affected tract.

(5) It is concluded that an appreciable increase in the incidence of malaria is not a necessary concomitant of canal irrigation, but that canal irrigation may become gravely prejudicial to health when it is wrongfully applied or improperly carried out.

(6) There is ample justification for the statement that canal irrigation has proved a great blessing (save in a few areas) and that, assuming water-logging is not allowed to arise, it is calculated to increase the wealth and prosperity of the Punjab, and to promote the health and well-being of its inhabitants.

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[1] Malaria in Amritsar—Special Report by Major C. A. Gill, I.M.S., Chief Malaria Medical Officer, Punjab. Punjab Government Press, Lahore, 1917.

THE USE OF HYDROCYANIC ACID GAS FOR THE FUMIGATION OF AMERICAN COTTON ON IMPORT INTO INDIA.

BY

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AND

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Within recent years the Mexican boll weevil (*Anthonomus grandis*) has been a constant menace to the American cotton crop. It has been estimated that when conditions have been favourable to its multiplication this weevil has in some seasons reduced the crop by about one-third. The boll weevil is at present unknown in India, and grave fears have been entertained that if it were once introduced it would work equal or greater havoc among the cotton crops of this country. Such an event would inevitably occasion tremendous losses to the cotton growers of India, seeing that with a low average price of cotton of say only four annas per pound, the total value of the Indian cotton crop is in the neighbourhood of sixty crores of rupees. The most likely mode of introduction of the boll weevil appears to be by means of American cotton bales imported into India. Experiments were therefore undertaken to ascertain the conditions under which hydrogen cyanide would be for such bales a fumigant sufficiently satisfactory to exterminate any boll weevils which might be present. It is proposed to describe these experiments in detail in a Memoir to be published shortly; in the following paragraphs only the results obtained are briefly indicated.

Experiments were carried out on three scales, *viz.*, small scale, one-bale scale, and full scale. Most of the experiments were carried out on the small scale, using a glass vessel (actually a large desiccator) as a container for the material being fumigated (cotton, etc.). The hydrocyanic acid gas was generated direct in this glass vessel; a method was worked out for sampling at intervals the atmosphere produced therein. The apparatus was found quite satisfactory for the purpose desired. Various chemical difficulties were encountered; among these was the effect of the presence of chloride as impurity in the cyanide used for the generation of HCN. Other interesting results obtained were that larger and more constant yields of HCN are produced when a little water is present in the cyanide-acid reaction; and that concentrated sulphuric acid is a strong absorbent of HCN.

Experiments were carried out to determine first what concentration of HCN and what duration of exposure are necessary in order to exterminate the weevils; and secondly whether the cotton or its jute covering may absorb and subsequently desorb HCN, and, if so, to what extent. In India the experiments were confined to a resistant weevil—the grain weevil, *Sitophilus oryzæ*—but it was subsequently arranged with the American authorities to repeat the work using the Mexican boll weevil itself.

It is concluded from the experiments that to ensure the extermination of the grain weevils under Bombay conditions it is sufficient to expose them for a period of 20 hours to a HCN-concentration of 150 parts HCN per 100,000 by volume (calculated as at normal temperature and pressure). The weevils were found to be much more susceptible to the influence of the HCN at higher than at lower temperatures, and it appears that a temperature of 86°F. is fairly critical, there being a marked difference in susceptibility on either side of this temperature.

From an examination of the experimental results for the Mexican boll weevil it appears that there is not a great difference in susceptibility between the grain weevil and the boll weevil, and that the temperature has an important effect on the susceptibility of the boll weevil also; if anything, the boll weevil is more sensitive than the grain weevil, at any rate to exposures for a comparatively short time at high HCN-concentration. The conclusion is drawn that under Bombay conditions the boll weevils would be exterminated by an exposure for 4 hours to a HCN-concentration of 450 parts HCN per 100,000 by volume or for 20 hours to a HCN-concentration of 150 parts HCN per 100,000 by volume (calculated as at normal temperature and pressure). For absolutely safe working on a practical scale it is further concluded that the best procedure is to combine a short-period fumigation (6 hours) at a high concentration with a long-period fumigation (a further 14 hours) at a lower concentration, the minimum initial concentration for the second period being 200 parts HCN per 100,000 by volume.

The conclusions drawn from the cotton absorption experiments were: (1) That cotton does absorb HCN, whether the cotton be loose or baled, dry or damp; (2) that damp cotton is rather more absorbent than dry cotton, although the difference in absorption even for extremes of humidity is not more than 50 per cent. of the total absorption; (3) that within the limits of temperature 86°—104°F. the actual temperature has very little influence either on the rate or on the degree of absorption of HCN by cotton; (4) that absorbed HCN is desorbed fairly rapidly and completely, and that there is no evidence of the occurrence of any irreversible chemical combination; (5) that with water present in the cyanide-acid reaction the weight of sodium cyanide required for satisfactory fumigation is about 0·05 per cent. of the weight of the cotton, but that where leakage has to be contended with—as when using barges on a practical scale—the weight of sodium cyanide required is about 0·07 per cent. of the weight of the cotton, or one pound weight of sodium cyanide for three bales of cotton. Subsequent experience on the

practical scale has shown, however, that one pound weight of sodium cyanide is sufficient for the satisfactory fumigation of about five bales of cotton, where good barges are used and the bales are both dry and also compressed to a high density. (6) That fumigation with HCN can be satisfactorily carried out on a large scale in barges.

The conclusions drawn from the jute absorption experiments were: (1) That jute has about twice the absorptive power of cotton, and moreover absorbs the HCN at a more rapid rate; (2) that the absorptive power of jute is only to a small extent dependent on its moisture content, being however slightly greater for damp jute than for dry; (3) that the absorptive power of jute remains practically unchanged through the temperature range 86°—104°F.

The results of these experiments led the Government of India to issue in November, 1925, a Notification under the Destructive Insects and Pests Act, 1914, prohibiting the importation of American cotton into India without fumigation with HCN and confining such importation to the port of Bombay. Experience which has since been accumulated in the application of this Notification to the fumigation of over 80,000 bales in barges, has amply confirmed the conclusions previously arrived at as to the absorptive capacity of cotton bales.

THE CONTROL OF MOSAMBI (*CITRUS AURANTIUM*) GUMMOSIS.

BY

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WITH the increasing growth in the Bombay Presidency of *Citrus* cultivation, there is unfortunately an equal increase in the number of diseases caused both by insect and vegetable parasites.

One of such diseases, which has taken serious proportions in recent years and is doing great damage to the *mosambi* (*Citrus aurantium*), forms the subject matter of this article.

Investigation is being carried out since 1923 into the real nature of this disease, which was so far considered to be due to certain physiological factors, mainly those of the soil. Several isolations carried out from the peeling bark obtained from the neighbourhood of the gummosis lesion have in the majority of cases given a *Phycomycetes* fungus as also a sp. of *Fusarium*; other organisms such as *Diplodia*, *Cephalosporium* and bacteria have also been obtained as is usual in such rotted tissue, and these are being used in the infection experiments now in hand.

Along with this investigation, experiments were regularly undertaken mainly with a view to bring the growing malady under control, owing to the large number of alarming reports that were received from garden owners of different centres.

Encouragement in this work was mainly derived from the American literature[1] on the subject, though some of the earlier experiments were carried out before this literature was available.

Several centres such as Rahuri, Rahata, Baramati, Junnar and Poona were selected in the Deccan and a large number of trees were treated in a manner to be subsequently described. The following table brings out the extent of damage as well as the number of trees receiving treatment at different centres.

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[1] Fawcett. *Jour. Agri. Res.*, XXIV, No. 3, 1923.

Fig. 1. A 3-year *mosambi* plant showing typical peeling of the bark starting from bud-union.

Fig. 3. A 8-year old *mosambi* plant with characteristic peeling of the bark and exudation of gum (centre) and perfect healing of the gummous lesion showing entire ribbon of callus (right) as a result of treatment.

Fig. 2. A 6-year *mosambi* plant showing extensive displacement of bark as a result of gummosis infection.

Fig. 4. A 3-year *mosambi* plant showing heavy infection resulting in death.

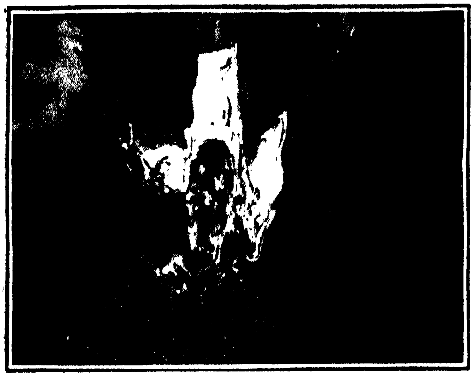

Fig. 1. A 6-year *mosambi* plant showing brown discoloration of internal wood, as a result of gummosis infection.

Fig. 2. A gummosis lesion carefully cut out preliminary to treatment.

Fig. 3. A *mosambi* plant affected with gummosis, showing perfect healing and callus formation of the wood and normal bearing as a result of treatment after one year.

TABLE I.

Statement showing the extent of damage and infection to the mosambi plantation.

No.	Place	No. of gardens	Total No. of plants in the garden	Total No. of plants affected	Percentage of infection
1	Baramati	1	500	60	12
2	Poona	2	336	78	21
3	Junnar	2	800	201	25
4	Rahata	2	1,200	252	21
5	Poona	1	1,121	103	9
6	Poona	1	1,800	101	6
7	Uruli	2	1,000	58	5
	TOTAL .	11	6,757	848	14·1

Before the actual method of treatment is detailed, it is necessary to describe the field characters of the disease as briefly as possible.

This trouble almost invariably occurs at the collar or crown of the tree, starting at the bud-union and always travelling further *up* and very rarely below that joint (Plate XXVIII, fig. 1). The most reliable symptoms for diagnosis are the peeling or breaking of the bark in a longitudinal manner (Plate XXVIII, figs. 1 and 2) at the spot, accompanied by exudation of amber coloured gum (Plate XXVIII, fig. 3); this is followed up, either immediately or later on, by the unhealthy appearance of the entire plant. In certain cases the entire plant suddenly dies, particularly if it is young (Plate XXVIII, fig. 4). The removal of this broken bark by a knife reveals the rotten discoloured wood below (Plate XXIX, fig. 1). These are the main and certain indications of gummosis.

TREATMENT.

THIS was carried out by using two different fungicides—(1) Crude carbolic acid, and (2) Bordeaux paste.

Once the seat of infection was clearly made out, the bark round about this infected area was carefully removed by a sharp knife, taking particular care not to injure the healthy wood below ; the extent of bark to be removed depends upon the extent of the wound and the brown discolouration caused as a result of gummosis infection. The *proper removal of the bark* has been found, by experience, to be an indispensable factor contributing to the successful control of the disease. The writer's experience with the treatment of this disease also shows, beyond doubt, that inasmuch as the gummous zone invariably extends *upwards*, the removal of the bark from the uppermost spot of the lesion is highly desirable (Plate XXIX, fig. 2).

This important factor upon which depends to a large extent the success or otherwise of the treatment, has been borne out by certain other conclusive proofs, which will form the subject of discussion separately.

Once the bark is properly removed the application of either of the fungicides, in a certain proportion, to be detailed below, to the entire lesion, taking special care to cover the edges of the wound, only remains to be done. This can be conveniently carried out by means of a strong brush and then the whole exposed wound is covered over by a thin paint of tar to protect it from any extraneous wood-attacking organisms.

The pieces of bark, obtained by scraping out the wound, are then collected and destroyed to prevent any further infection.

The proportions of ingredients used in the treatment are given below :—

I. *Crude carbolic acid.*

Acid	1 part.
Water	1 part.

II. *Bordeaux paste.*

Copper sulphate	1 lb.
Unslaked lime	2 lb.
Water	16 lb.

Method of preparing Bordeaux paste. The crystals of copper sulphate (1 lb.) are tied in a thin cloth and allowed to dissolve in 8 lb. of water in a earthen pot. The lime is then slaked in another pot, by slowly sprinkling the rest of water over it, and then made into a solution. Both these solutions are then poured into a third pot, stirring all the while : the whole is now ready for use.

Both these fungicides have given very satisfactory results ; this treatment was able not only to stop the exudation of the gum, so characteristic a symptom of this deadly disease, but also entirely arrested the onward march of the disease and assisted the process of healing and callus formation that immediately followed the treatment (Plate XXIX, fig. 3 ; Plate XXVIII, fig. 3).

TABLE II.

Statement showing the results of treatment against gummosis.

No.	Place	Date of treatment	No. of plants treated	No. of plants fully revived	No. of plants failed	Percentage of failure	Date of last observation	Remarks
1	Baramati	15-6-1924	60	55	5	8·4	January 1925	After six months
2	Poona	Oct. 1924	73	65	8	11·0	22-4-26	After 2 years
3	Junnar	Feb. 1925	201	200	1	0·5	23-4-26	After 1¼ years
4	Rahata	Aug. 1925	252	244	8	4·8	12-4-26	After 8 months

The infection was very heavy at the time the treatment was carried out, and the owners, particularly at Rahata and Junnar, had given up hopes of any improvement of their gardens: the plants had distinctly yellow leaves These gardens at present are in striking contrast to their former condition and are showing full vigour, good bearing and dark green leaves.

It will be noticed that the number of plants treated as also the period allowed for recoupment were sufficiently long to ensure reliability of the final results.

The writer is highly indebted to Dr. W. Burns, D.Sc. (now Joint Director of Agriculture, Bombay Presidency) for all the assistance and encouragement rendered by him during the progress of this investigation.

APPENDIX.

Statement showing the cost and labour required for the treatment against gummosis.

I. CARBOLIC ACID TREATMENT—FOR 150 TREES.

Ingredients	Quantity	Cost
		Rs. a. p.
Carbolic acid	1 lb	1 4 0
Labour required at 0-12-0 per day per man	6 men	4 8 0
Coal tar	..	0 8 0
TOTAL .	..	6 4 0

II. BORDEAUX PASTE—FOR 150 TREES.

Ingredients	Quantity	Cost
		Rs. a. p.
Copper sulphate	½ lb.	0 4 0
Unslaked lime	1 lb.	0 0 6
Labour at 0-12-0 per day per man	Six men	4 8 0
Coal tar	..	0 8 0
TOTAL .	..	5 4 6

These figures could be considerably reduced if the garden owner gets his men trained up in the operation, and does not depend upon outside help.

HOME-MADE BONE SUPERPHOSPHATE AND ITS EFFECT ON POTATOES.*

BY

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The yield of field crops is influenced by a number of factors, such as seed, weather, soil preparation, manuring, irrigation, care in harvesting, etc. Although all these factors are jointly responsible for an increase or decrease in the yield of any particular crop, yet the supply of adequate food material is one of the most important amongst them. Unless proper attention is paid to this, neither the best selected seeds nor the farmer's skilled soil management can fully reward him for his labours.

Of the principal manurial ingredients required for the growth of crops, nitrogen and phosphoric acid are the two in which the Indian soils have been found to be most deficient. A partial supply of the former element is gained from the atmosphere, through the agency of a special class of micro-organisms, the nitrogen-fixers, and the remainder can be supplied either in the form of chemical fertilizers such as ammonium sulphate, nitrate of soda, cyanamide, etc., or in the form of organic manures such as farmyard manure, oil-cakes, leaf mould and other plant residues, town refuse, night soil, sewage, guanoes, etc., at a moderate cost. Another cheap source is the practice of green-manuring which, if practised by the method evolved at Pusa, would be found very economical.

The natural sources in this country whence the soil can meet its demand for phosphoric acid, are first a few existing beds of rock phosphate scattered here and there in certain localities. This product requires a great deal of labour in digging and in its further treatment such as fine grinding, etc. Furthermore, its phosphoric acid content is in such a state that unless the powdered mass is chemically

* Paper read at the Indian Science Congress, Lahore, 1927.

treated it is of little or no use to plants. Other natural sources of its supply are bones and fish manures which are no doubt better than the one referred to above, but these materials too require some chemical treatment for the desired aim to be fulfilled. Artificial manures such as basic slag and superphosphate also supply phosphoric acid to the soil. Superphosphate is derived from a raw product like bones or rock phosphate by treatment with sulphuric acid. Such treatment necessarily increases the cost of manure.

With a view to supplying this important element at a smaller cost than that incurred by the purchase of superphosphate, a method has been devised by which any farmer can prepare his superphosphate on his own farm with the help of bacteria. The operations which are carried out in factories with costly machinery and chemicals for converting the insoluble phosphate into superphosphate are all represented in this cheap method in a small heap under a thatched roof, in a mud-walled room, where sulphur-oxidizing bacteria will be always at work, day and night, at a cost of mere water supply and without any highly paid supervisors to look after their work. The method suggested here is a simple one which a farmer of ordinary intelligence can safely adopt. It consists in preparing a mixture of raw phosphatic products with sulphur, sand and water, and a little inoculum of sulphur-oxidizing bacteria, derived from a previous mixture.

The raw material recommended by the writer is bones, which are available at any place in India at a moderate cost. Besides being easily and cheaply available, bones when fairly dry can be easily crushed to the desired degree of fineness in an ordinary mortar mill with a pair of bullocks and a driver. When the ground bones are at hand what the cultivator needs do is to purchase a little sulphur and get some sand from the neighbouring river or brook. A mixture of all these is then prepared in the recommended proportions and the mass is allowed to ferment for a period of about 6 to 8 months under shade.

Before undertaking the process, some of the important factors which are essential for success should be understood. These factors are :—

(1) The proper size of the particles of the powdered bones. A number of experiments in the laboratory have shown that the finer the grinding, the quicker and more complete is the solubilization of the bones. This is due to the increase in the superficial area of the material which comes in contact with the acid produced in the heap from the oxidation of sulphur. Finely ground substance, bone-dust, when used for the experiment yielded up to 96 per cent. of the total phosphoric acid in an available form, while in the case of coarser material, bone-meal, 65 per cent. was found to be available in the same period. It will be seen from the following table that 35 per cent. of the particles of bone-meal were over 1 mm. in diameter. all of the bone-dust particles were less than 1 mm. in diameter.

Mechanical analysis of bone-dust and bone-meal.

Particles bigger than	Bone-dust	Bone-meal
	per cent.	per cent.
2 mm., or 4/50 inch	0	5
1 mm., or 2/50 inch	0	30
½ mm., or 1/50 inch	16	17
100 meshes to an inch	48	32
Passed through 100 mesh sieve	36	16
TOTAL	100	100

(2) Maintenance of air and water supply. (*a*) All living beings require water and bacteria do not form an exception to this rule. A constant supply of water is very essential for their activities. The optimum moisture requirement is 20 to 25 per cent. of the weight of the heap. It should not exceed above 30 per cent., to avoid interference with the friability of the heap. In order to avoid great variation of moisture in the heap it should be kept in a room the floor of which should be firm and well rammed with stones. Cemented floors have been found to be unsatisfactory in our experiments, because the cement is eaten away by the acid produced in the heap. (*b*) Besides being necessary for keeping bacteria alive, air is required for the oxidation of the sulphur and the formation of sulphuric acid which reacts with the insoluble phosphates. Aeration can be best obtained by adding some inert substance like sand or soil. Sand and a number of soils were tested in the laboratory for their efficiency. Sand being inert has been found to be the best. Soils containing little lime can be used at the cost of a slight lowering of the efficiency, due to the neutralization of some portion of the oxidized sulphur by soil constituents.

(3) Protection from adverse climatic factors. To check the hot dry winds of summer from drying the heap it is essential that it should be protected by side walls, and to prevent washing out by rains, some kind of roof will have to be provided; a thatched roof is cheap and quite satisfactory.

Recent experiments have shown that the addition of powdered charcoal to the extent of 6 per cent. of the weight of compost increases the rate of solubilization of phosphoric acid.

From the numerous experiments conducted by the writer the following proportions of the different ingredients have been found to be most suitable for preparing the compost :—

Bone-meal	100 parts
Sulphur	25 parts
Sand	100 parts
Water	20—25 per cent. of the weight of compost.
Charcoal	6—7 per cent. of the weight of compost.

To test the manurial value of the composts, experiments were conducted with potatoes in 1924-25 and 1925-26. The choice fell on potatoes because of its being one of the principal food crops of the world, and a crop which is well known for responding to the application of fertilizers. A number of trials at different places has shown that nitrogenous and phosphatic manures, especially the latter, when applied with a basal dressing of farmyard manure, increase the yield of potatoes. Potash has been found to be useful in some soils, but often the increase in yield with potassic manures has not been enough to cover the cost of fertilizers. The present experiments therefore were restricted to the use of nitrogen and phosphoric acid only. Composts prepared in the laboratory with two kinds of material, bone-meal and bone-dust without the addition of charcoal, were used, and both of these composts proved to be better than either bone-meal or superphosphate. The effect of the compost with charcoal is being tested during the current season on certain other crops also, *viz.*, chillies, tobacco, onions, oats and mustard.

The first trial was made in 1924-25 with a local variety of potatoes in a small plot which had not received any manure, nor had it grown any crop during the preceding 4 years. After the usual necessary cultivation potatoes were planted by the middle of October. Manures were applied in two doses at the rate of 50 lb. phosphoric acid per acre each time, the first being 3 weeks after planting and the second a month later, making 100 lb. in all. Harvesting was done by the middle of February, a little before the crop was fully ripe, because porcupines had started to take an unwelcome interest in the experiments.

The following table shows the yields in maunds of potatoes per acre :—

Treatment	Yield of potatoes maunds per acre	Per cent. increase over control
Bone-meal-sulphur compost	168	42
Bone-meal compost, no sulphur	132	12
Superphosphate	159	35
Control	118	..

Taking superphosphate at Rs. 90 per ton, bone-meal at Rs. 120 per ton and sulphur at Rs. 145 per ton, the cost of manuring an acre of land comes to—

	Rs.
Compost with sulphur	31
Compost without sulphur	24
Superphosphate	20
Control	nil

With a crop valued at Rs. 2-8-0 per maund the returns per acre come to :—

	Value of crop	Cost of manure	Net profit over control
	Rs.	Rs.	Rs.
Compost with sulphur	420	31	94
Compost without sulphur	330	24	11
Superphosphate	395	20	80
Control	295	nil	..

These figures show that the most economical manure was the compost with sulphur. It may also be pointed out that the cost of bone-meal will be much less if the bones can be crushed locally in an ordinary mortar or *surkhi* mill.

Further experiments on the effect of bone-dust compost on the yield of potatoes were carried out in 1925-26. The variety of potatoes grown and the cultivation given were the same as in the previous year. Manures were applied at the rate of 100 lb. P_2O_5 per acre in a single dose 3 weeks after planting. The following table shows the yield of potatoes in maunds per acre :—

Treatment	Yield maunds	Per cent. increase over control
Bone-dust-sulphur compost	92·5	38
Bone-dust compost, no sulphur	88	31
Superphosphate	86	28
Control	67	..

Thes figures like those of the previous year clearly establish the superiority of the compost with sulphur over the other manures.

Summary.

(*a*) An easy and a successful method has been devised for the production of soluble phosphate by the cultivator.

(*b*) The manure prepared by this method is superior to untreated phosphates or superphosphate for use on the potato crop.

PHYLLOTAXIS AND LEAF-OBLIQUENESS AS SEPARATION CHARACTERS IN SEEDLING CANES.

BY

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I. Introductory.

Increasing attention has been paid to cross-breeding work in sugarcane since the nineties of the last century when it was resorted to in Java, chiefly for obtaining disease-resistant types. Cross-bred canes have multiplied from that period onwards, and Java, India, Barbados and other cane producing countries have now their own improved seedling canes to replace the older types.

It is in certain cases rather difficult to distinguish from one another seedlings which are similar in appearance and as the seedlings have ultimately to go to the cultivator, an easy means of identification is of great importance. But in the case of vegetatively reproduced crops like the sugarcane, the floral characters are often not available and one is forced to depend entirely on the vegetative characters. Vegetative characters which in other plants might be overlooked, often serve to separate one set of canes from another. Characters based on the measurement of parts or the relative proportion of one part to another (*e.g.*, leaf-sheath/lamina, etc.) are good in their way, but their utility in the field for separating allied canes is rather limited. Definite and easily distinguishable morphological characters would seem to be desirable as guides to identification.

Attempts to provide keys for identifying grasses by their vegetative characters have previously been made by M'Alpine,[1] Ward,[2] Percival[3] and Lyman Carrier.[4]

While studying the morphological characters of seedlings and varieties, it was observed that the arrangement of leaves on the shoot and the asymmetry or inequality in width between the two halves of the lamina (on either side of the midrib) are two characters in regard to which the seedlings or the varieties of sugarcane differ among themselves. These characters are easily noticed in the field and while not of absolute classificatory value, are yet of use chiefly as additional confirmatory characters in identifying closely allied seedlings or varieties.

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[1] M'Alpine, A. N. How to know grasses by the leaves. *Standard Cyclopedia of Modern Agri.*, Vol. VI, p. 153, 1890.

[2] Ward, H. M. *Grasses*, pp. 39 to 61, Cambridge, 1901.

[3] Percival, John. *Agricultural Botany*, pp. 560 to 563, London, 1918.

[4] Carrier, Lyman. The identification of grasses by their vegetative means. *U. S. Dept. of Agri. Bull.* 461, 1917.

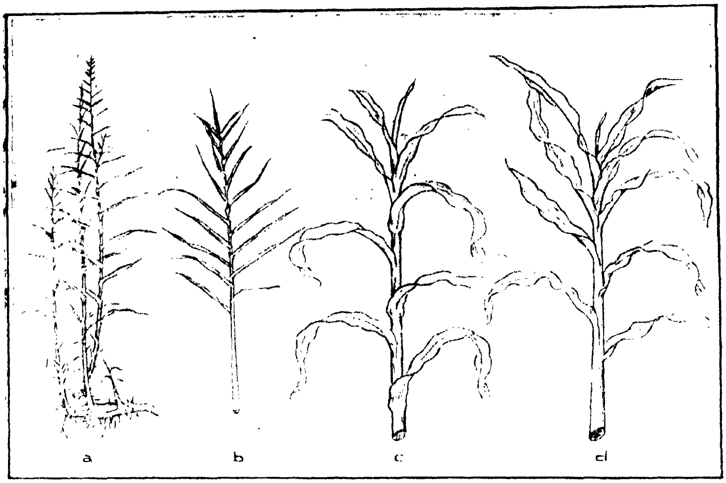

Fig. 1. (*a*) showing a portion of clump of *Arundo Donax*, L.
(*b*) central shoot of (*a*) shown separately.
(*c*) a shoot of sorghum showing disturbed phyllotaxis.
(*d*) another shoot of sorghum showing regular distichous arrangement.

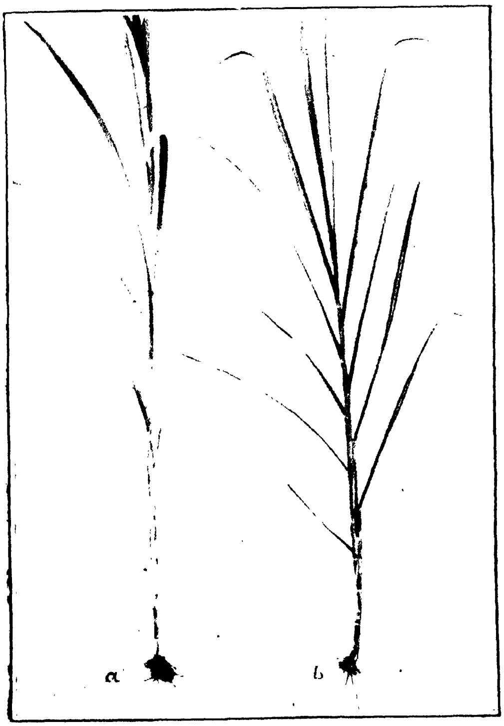

Fig. 2. (*a*) Co. 210 showing disturbed arrangement.
(*b*) Co. 281 showing typical distichous arrangement.

PLATE XXXI.

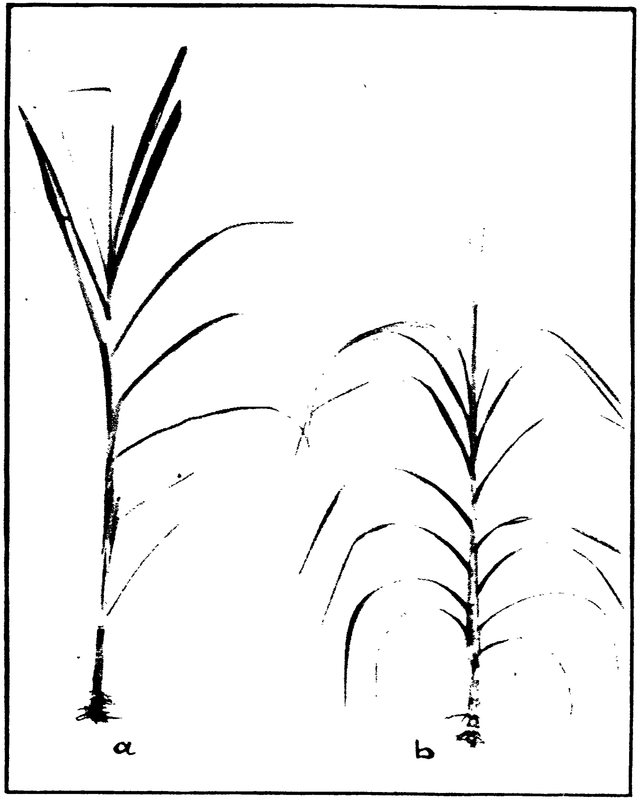

Fig. 1. *a*. P. O. J. 2688 showing disturbed arrangement.
b. B. 6308 showing typical distichous arrangement.

Fig. 2. *a*. P. O. J. 2690. Leaf asymmetrical.
b. Co. 210. Leaf asymmetrical.
c. B. 6308. Symmetrical leaf.

II. Phyllotaxis.

The leaf arrangement in grasses is typically distichous, the angular divergence between two successful leaves being 180°. This typical arrangement was found to be absent in some seedlings and varieties under study. Co. 205, Co. 210 and Co. 304 among seedlings and Katha and Saretha (Partabgarh) among varieties are some of the instances showing a disturbed phyllotaxis (*i.e.*, leaves not typically distichous). The top of the leaf-sheath of the alternate leaves shifts about a quarter of the circumference so that the angular divergence between the two orthostichies comes to be about 90°. This results in a crowding together of the leaves on one side, presenting a vacant appearance on the other. The place of origin of the leaf-sheath, however, remains in the usual distichous position. This has been termed as disturbed phyllotaxis (Pl. XXX, fig. 2a and Pl. XXXI, fig. 3a). In Pl. XXX, fig. 2b and in Pl. XXXI, fig. 3b, one row of leaves is on the right and the other on the left showing the typical distichous arrangement. In fig. 2a on Pl. XXX, the second row instead of being on the right and in fig. 3a on Pl. XXXI on the left, faces the observer. The lower three laminas have been cut to show the arrangement.

For comparison the phyllotaxes of the following grasses were also studied :— *Arundo Donax* L., elephant-grass (*Pennisetum purpureum* Schum.) and guinea-grass (*Panicum maximum* Jacq.). The shoots examined were from the same clump which was carefully washed before dissection. The relative proportions of disturbed to distichously arranged shoots per clump or row in each case are :—

	Head row No.	Disturbed arrangement	Distichous arrangement
Guinea-grass	1st clump	23	30
	2nd clump	41	50
Elephant-grass	..	11	21

Fig. 1a on Plate XXX shows a portion of clump of *Arundo Donax* L. In the shoots on the right and left the leaves are distichously arranged, while in the central shoot both the distichous and the disturbed arrangements are present. Fig. 1b separately shows this shoot and it may be noticed that four orthostichies arise as a result of the irregularity of the leaf arrangement, if the whole shoot is taken into account. From among the grasses observed, *Arundo Donax* L. stands by itself in this respect. There are, however, only two rows of leaves giving the two-ranked arrangement in any particular portion of the shoot.

For sugarcanes, Co. 281 and Co. 210 show striking differences in phyllotaxis. Two-month and six-month crops have been studied in both the seedlings to find

out indications of differences, if any, between the younger and the older stages of the plant in relation to leaf arrangement. The relative proportions of the disturbed and distichously arranged shoots are :—

	Disturbed	Distichous	Total disturbed	Total distichous
Co. 281—				
2 months	5	141	15	297
6 months	10	156		
Co. 210—				
2 months	174	29	551	53
6 months	377	24		

It will be noticed that a small percentage of disturbed arrangement shoots in Co. 281 and distichously arranged shoots in Co. 210 are met with. This brings out the fact that phyllotaxis is not an absolute character ; nevertheless the presence in a majority of cases of a particular type of leaf arrangement in a seedling or a variety suffices for practical purposes to put it down as showing the disturbed or the distichous arrangement.

In thick tropical canes the typical distichous arrangement seems to be the rule. Out of thirty-seven varieties and seedlings examined for this purpose, only Vellai, J. 247, P. O. J. 2688 and P. O. J. 2690 were observed to show disturbed shoots and in each case the percentage was negligible.

III. Obliqueness of leaf.

It is perhaps generally known that in the sugarcane leaf the halves of the lamina on either side of the midrib are unequal in width. That this asymmetry or obliqueness is constant for a particular seedling or a variety is seen from the table below. It will also appear that seedlings and varieties differ as to the extent in the leaf in which obliqueness is noticed. All grades from oblique practically the entire length, oblique up to middle, oblique up to basal one-third, to more or less symmetrical leaves are met with. The measurements in the subjoined tables were made on leaves taken from the row of canes without any attempt at selecting any particular leaf. Table I gives the averages based on measurements of 195 leaves. Table II gives the actual measurements of ten leaves from two of the seedlings.

TABLE 1.

Showing measurements of lamina halves in Co. 210 and Co. 281.

Seedling	Class value	Two-month crop: BASE, Narrow half	Two-month crop: BASE, Wide half	Two-month crop: MIDDLE, Narrow half	Two-month crop: MIDDLE, Wide half	Two-month crop: TOP, Narrow half	Two-month crop: TOP, Wide half	Class value	Six-month crop: BASE, Narrow half	Six-month crop: BASE, Wide half	Six-month crop: MIDDLE, Narrow half	Six-month crop: MIDDLE, Wide half	Six-month crop: TOP, Narrow half	Six-month crop: TOP, Wide half
Co. 210	c.m.							c.m.						
	0·50—0·60	..	..	..	..	11	5	0·80—0·90	37	..	..	..	1	1
	0·60—0·70	6	..	1	..	9	9	0·90—1·00	11	17	..	..	5	3
	0·70—0·80	13	2	4	..	4	10	1·00—1·10	14	15	..	..	3	2
	0·80—0·90	5	13	7	2	..	..	1·10—1·20	8	13	..	..	4	4
	0·90—1·00	1	6	7	7	..	..	1·20—1·30	..	19	6	1	20	9
	1·00—1·10	..	2	6	11	..	..	1·30—1·40	..	1	6	..	7	13
	1·10—1·20	..	2	..	4	..	..	1·40—1·50	..	4	20	4	14	12
	1·20—1·30	..	..	..	1	..	..	1·50—1·60	..	1	22	9	3	9
								1·60—1·70	..	..	9	16	1	5
								1·70—1·80	..	..	5	21	1	..
								1·80—1·90	..	..	2	14	..	1
								1·90—2·00	..	..	..	4	..	..
								2·00—2·10	..	..	..	..	..	..
								2·10—2·20	..	..	..	1	..	..
	Average .	0·76	0·88	0·90	1·04	0·63	0·65	Average .	0·95	1·10	1·51	1·71	1·23	1·30
Co. 281	c.m.							c.m.						
	0·50—0·60	10	..	..	..	4	2	0·70—0·80	5	1	..	..	..	..
	0·60—0·70	9	5	..	..	13	7	0·80—0·90	5	..	..	..	..	..
	0·70—0·80	6	13	9	6	6	13	0·90—1·00	14	3	..	..	1	..
	0·80—0·90	..	7	10	12	2	3	1·00—1·10	18	11	4	3	8	7
	0·90—1·00	..	..	5	6	..	..	1·10—1·20	18	23	5	5	4	5
	1·00—1·10	..	..	1	1	..	..	1·20—1·30	8	18	8	9	11	8
								1·30—1·40	7	12	6	4	13	16
								1·40—1·50	..	3	11	9	12	9
								1·50—1·60	..	3	12	15	5	7
								1·60—1·70	..	1	12	12	3	4
								1·70—1·80	..	..	8	6	2	2
								1·80—1·90	..	..	4	7	..	1
								1·90—2·00	..	..	4	3	..	..
								2·00—2·10	..	..	..	1	..	..
								2·10—2·20	..	..	1	1	..	..
	Average .	0·64	0·75	0·80	0·84	0·72	0·77	Average .	1·08	1·23	1·50	1·55	1·34	1·38

TABLE II.

Seedling	No.	Two-month crop						No.	Six-month crop					
		BASE		MIDDLE		TOP			BASE		MIDDLE		TOP	
		Right half	Left half	Right half	Left half	Right half	Left half		Right half	Left half	Right half	Left half	Right half	Left half
Co. 210	1	0·96	0·64	1·03	0·80	0·75	0·66	1	1·15	1·45	1·45	1·86	1·13	1·13
	2	0·95	0·79	1·13	0·98	0·77	0·67	2	1·25	0·97	1·73	1·55	1·35	1·24
	3	0·80	0·63	0·95	0·85	0·58	0·52	3	1·55	1·15	1·88	1·55	1·38	1·28
	4	0·81	0·95	1·08	1·18	0·69	0·75	4	1·03	0·87	1·73	1·53	1·18	1·07
	5	0·86	0·70	0·94	0·90	0·58	0·58	5	1·13	1·23	1·51	1·75	1·00	1·12
	6	0·90	0·78	1·05	0·90	0·71	0·70	6	1·00	1·15	1·58	1·62	1·00	1·00
	7	0·74	1·03	0·92	1·05	0·75	0·75	7	1·21	1·00	1·61	1·47	0·85	0·85
	8	0·98	0·80	1·10	1·04	0·72	0·73	8	1·22	1·09	1·90	1·75	1·40	1·40
	9	0·85	0·80	1·20	1·07	0·73	0·73	9	1·20	0·90	1·90	1·60	1·35	1·28
	10	0·84	0·64	0·90	0·78	0·70	0·64	10	1·26	1·12	1·82	1·61	1·51	1·39
Co. 281	1	0·61	0·70	0·71	0·75	0·68	0·70	1	1·38	1·30	1·85	1·90	0·96	1·01
	2	0·62	0·73	0·82	0·83	0·68	0·77	2	1·27	1·35	1·60	1·58	1·19	1·23
	3	0·84	0·56	0·85	0·80	0·80	0·70	3	1·10	1·19	1·70	1·70	1·57	1·57
	4	0·90	0·65	0·85	0·83	0·73	0·62	4	1·35	1·15	1·84	1·78	1·83	1·78
	5	0·55	0·69	0·78	0·78	0·60	0·65	5	1·20	1·35	1·80	1·80	1·50	1·55
	6	0·73	0·60	0·85	0·72	0·64	0·57	6	1·30	1·19	1·73	1·73	1·35	1·35
	7	0·75	0·72	0·82	0·82	0·59	0·46	7	0·84	1·00	1·40	1·43	1·37	1·35
	8	0·88	0·75	0·75	0·75	0·73	0·65	8	1·05	1·14	1·76	1·76	1·58	1·62
	9	0·65	0·78	0·90	0·95	0·70	0·70	9	1·25	1·14	1·92	1·92	1·50	1·56
	10	0·68	0·72	0·90	0·90	0·70	0·55	10	1·05	1·10	1·60	1·58	1·45	1·49

From the above table it is seen that Co. 210 is oblique throughout its whole length. A difference of about two millimeters at base and middle between the two halves in the two-month as well as the six-month crop is easily noticed by the naked eye. There is a difference at the top also but it is not appreciable. In Co. 281 the lamina halves are appreciably unequal in width at base. The difference at middle and top though noticeable when measured with calipers is not appreciable to the eye. Fig. 2 on Plate XXXI shows the symmetrical and asymmetrical leaves. It will be noticed that the eye perceives the difference in width between the two halves in Fig. 2*a* and Fig. 2*b*. The halves in Fig. 2*c* are practically symmetrical though not absolutely true to the calipers.

The measurements in the above tables have been supplied to provide the statistical basis for eye judgment. The eye very easily detects a difference, if there is any, between the widths of the two halves of the lamina, and it is possible to say without measuring whether a particular leaf is from Co. 210 or Co. 281 shoot. It cannot be denied that leaf-obliqueness like phyllotaxis is not an absolute character, but it is an easily recognizable one and as such is preferable to very minute and obscure characters. Very often it may happen that these two characters (leaf-obliqueness and phyllotaxis) are the same or not very different for the seedlings intended to be compared, but their value chiefly lies in being easily noticeable and as additional characters for identification.

My thanks are due to Mr. S. U. Khan, Superintendent, Central Farm, Coimbatore, for affording facilities for observations in guinea-grass. Botany Assistant M. P. Gourisankara Ayyar has been of great help in taking measurements.

INHERITANCE OF THE NUMBER OF BOLL LOCKS IN COTTON AND THEIR RELATION TO YIELD*.

BY

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One of the very characteristic differences between the bolls on the same or different cotton plants is the prevalence of bolls containing a varying number of sections or loculi. The number of such loculi varies from two to six. No bolls have been found in any variety with less than the former or more than the latter number. But within the range stated it will easily be seen that there is a very great chance that the yield may be affected by the existence of many bolls containing a larger or a smaller number, and it might even be possible to develop strains which have exclusively, or almost exclusively, bolls containing such a larger number. Thus the investigation of the way in which this character is inherited assumes considerable importance.

The opportunity for such investigation came to me in the study of the crossing of an American Upland type of cotton known as Gadag No. 1 (*Gossypium hirsutum*) and a strain of Sea Island cotton (*Gossypium barbadense*). This crossing was undertaken primarily to obtain a cotton of the American type, suitable for Dharwar and adjoining districts, with improved staple. But a number of other interesting and important points have appeared during the course of the study, of which the study of inheritance of the boll loculi or locks is one. It has been possible to follow this inheritance through the progeny in four hybrid generations (F_1, F_2, F_3, F_4), in each of which complete self-fertilization was provided for.

The inheritance of the number of boll locks has been studied by several workers in the past, and a summary of the results of these studies was given in "The Agricultural Journal of India" (Vol. XIX, p. 297, 1924). Balls,[1] for example, found that the number of boll locks was hereditary, and that strains of Egyptian, American, and hybrid cottons could be obtained and isolated which, consistently from generation to generation, gave a higher or lower number of boll locks than

* This investigation was conducted at Dharwar under the auspices of the Indian Central Cotton Committee.

[1] *The Cotton Plant in Egypt*, London, 1919.

the average. In America, Kearney[1] obtained selections in Pima cotton with a higher percentage of four lock bolls than the average, and concluded that the tendency towards the production of such bolls was a hereditary character. A similar conclusion was reached recently by Harland,[2] as a result of the study of hybrids between several strains of Sea Island cotton, and between a West Indian perennial and a pure strain of Upland American cotton.

In cotton, as has already been noted, it is usual to find the capsule (or the boll) divided into two to six locks or loculi, but two and six locked bolls are rare. On a single plant there may be a mixture of bolls containing a different number of locks, or all the bolls may be similar in this respect. Plants carrying bolls with two, five or six locks *only* are, however, not known. In the cotton under study (Gadag No. 1 and Sea Island) and their hybrids as grown at Dharwar, plants have been found bearing (*a*) two and three locked bolls (very rare), (*b*) three to four locked bolls (most common), (*c*) three, four, and five locked bolls (common), and (*d*) four and five locked bolls (rare). The actual relative proportion of three, four and five locked bolls from a series of plants taken together has been as follows :—

	Proportion			
	3-locked bolls	4-locked bolls	5-locked bolls	Mean number of locks
	Per cent.	Per cent.	Per cent.	
Gadag 1	6·2	85·3	8·5	4·0
Sea Island	93·8	6·2	0·0	3·1
First generation hybrid (F_1)	49·2	50·3	0·5	3·5
Second generation hybrid (F_2)	5·7	42·7	1·6	3·5

*The mean number of boll locks was found in each case by counting the number of bolls with different lock numbers from the bolls on each plant. All bolls were included which were large enough early in February to permit the determination of the number of locks.

The actual distribution of the mean value, plant by plant, in the above four types of plant is shown in the following table. The number of plants examined

[1] Hereditable variations in an apparently uniform variety of cotton. *Jour. Agri. Res.*, Vol. XXI, No. 4.

[2] The inheritance of the number of boll loculi in cotton. *Jour. Text. Inst.*, XIV, 12.

in each case varied from 145 in the case of Sea Island cotton to 500 in the case of the second generation hybrid. The figures given are percentages.

Mean number of locks per plant	Gadag 1	Sea Island	First generation hybrid (F_1)	Second generation hybrid (F_2)
	Per cent.	Per cent.	Per cent.	Per cent.
3·0—3·1	..	90	..	28
3·2—3·3	..	10	16	20
3·4—3·5	..	..	39	18
3·6—3·7	4	..	34	13
3·8—3·9	13	..	11	9
4·0—4·1	66	..	..	10
4·2—4·3	14	..	..	1·5
4·4	3	..	..	0·5

It will be seen that the mean number of boll locks in the two parents of the cross is quite different, and that the number of locks in the first generation hybrid is almost exactly the arithmetic mean of that of the parents. The variability is, as would be expected, very high in the second generation, but the mean is almost exactly the same as in the first generation of the cross.

The problem before us is to find out how far the character of giving a high percentage of four locked bolls can be transmitted, and thus how far it is possible to obtain, in a Sea Island hybrid, a cotton breeding true with the large number of boll locks which is characteristic of the Upland American type (Gadag 1) used. This has been now traced in the third and fourth generations of the cross with very clear results.

The method adopted in the third generation of the cross was to take the whole of the seeds from plants of the second generation (F_2) whose mean boll lock number is known, and determine the mean number of locks per boll in each plant produced in the following generation (F_3). It may be stated at once that, as would be expected in the case of the inheritance of a definite character, the plants can be divided into

those whose progeny all have a mean value similar to the parent, and those which vary widely. The actual summarized results are as follows :—

Mean boll-locks in parent	Total number of families	Number of families with various mean boll lock numbers							
		3·0 3·1	3·2 3·3	3·4 3·5	3·6 3·7	3·8 3·9	4·0 4·1	4·2 4·3	4·4 4·5
3·0	7	3	4	..	..	..	..	..	..
3·1	9	4	5	..	..	..	..	..	..
3·2	7	1	5	1	..	..	..	..	..
3·3	8	2	5	1	..	..	..	..	..
3·4	10	..	5	4	1	..	..	..	..
3·5	9	..	5	4	..	..	..	..	..
3·6	6	..	1	2	3	..	..	..	..
3·7	2	..	..	..	2	..	..	..	..
3·8	4	..	..	..	3	1	..	..	..
3·9	5	..	..	..	3	2	..	..	..
4·0	3	..	..	..	..	2	1	..	..
4·1*	3	..	..	..	..	2	1	..	..
4·2	3	..	..	..	..	..	3	..	..

The correlation, in selfed material, between the second and third generation in the matter of the proportionate number of bolls with different numbers of boll locks is very close. In the succeeding generation (F_4) it was possible to determine whether there was any fixation of the character, and by comparing the number

of boll locks in selfed plants in four successive generations the figures given in the following series of tables were obtained.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 progeny
I.			
3·0	3·0	3·0 3·1 3·1	All these three give from 3·0 to 3·1 ; thus breeding true.
3·0	3·2	3·0 3·1 3·3 3·4 3·8	All these five breed from 3·0 to 3·1 ; thus practically breeding true.
3·0	3·3	3·1 3·2 3·4 4·0	These give 3·1 to 4·0 ; thus showing a splitting.
3·0	3·1	3·0 3·1 3·3 3·7 3·8	These give from 3·1 to 3·5 ; they are still splitting.
3·0	3·0	3·0 3·1 3·2	All these three breed from 3·0 to 3·1 and so breed true.

Out of five F_3 families tested, three breed true.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 progeny
II.			
3·1	3·2	3·6 3·8 3·9	Breed from 3·3 to 3·7 ; thus splitting.
3·1	3·1	3·0 3·3 3·8	These give 3·1, thus breeding true.
3·1	3·1	3·1 3·2	Both these give 3·1 and 3·2, so practically breed true.
3·1	3·2	3·5 3·6	Both give 3·2 and so breed true.
3·1	3·3	3·3 3·4 3·5 3·7 3·9 4·0	Breed from 3·2 to 3·7 and are still splitting.

Out of five F_3 families, three breed true in the F_4 generation.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 progeny
III.			
3·2	3·2	3·0 3·4	Give from 3·0 to 3·1 and so are not breeding true.
3·2	3·3	3·3 3·6	Both give 3·2 and hence breed quite true.
3·2	3·1	3·1 3·2 3·4	All give 3·1 and so breed true.

Out of three F_3 families tested two breed true.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 progeny
IV.			
3·3	3·3	3·6 3·7	Both give 3·3 and hence breed quite true.
3·3	3·3	3·5 3·7 4·0	All the three give 3·5 value and hence are not quite true to the parents.

Only two F_3 families were tested, out of which one breeds quite true.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 progeny
V.			
3·4	3·2	3·0 3·1	Both give nearly the same value, *viz.*, 3·06 and hence do not breed true.
3·4	3·4	3·2 3·5 4·0 4·0	These give from 3·3 to 3·5 and hence taken as one array breed true.
3·4	3·6	3·4 3·8 4·1	Give from 3·4 to 3·5 and thus breed true.
3·4	3·4	3·0 3·5 3·7	These give from 3·5 to 3·8 and hence do not breed true.

Out of four F_3 families, two only breed true.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 family.
VI.			
3·5	3·2	3·0 3·3	These give 3·1 and 3·2 and hence breed true to F_3 family value.
3·5	3·5	4·0 3·6	Both give 3·5, thus breeding quite true.

Out of two F_3 families tested, one breeds quite true.

VII.			
3·6	3·4	3·2 3·7	Both give 3·2 and so do not breed true.
3·6	3·6	3·3 3·7	Both give 3·6 and hence are quite true to the parents.
3·6	3·5	3·1 3·2 3·3 3·4 3·7	All these breed from 3·04 to 3·4 and hence are splitting.

Out of three F_3 families tested, one only breeds quite true.

VIII.			
3·7	3·6	3·2 4·0	These give 3·6 and 3·7 and so practically breed true.

The one F_3 family tested breeds true.

IX.			
3·9	3·9	3·4 3·5 3·9	These give from 3·8 to 3·9 and breed quite true.
3·9	3·7	3·6 3·9	These give 3·3 and 3·5 and thus do not breed true.
3·9	3·6	3·4 3·5	These give 3·2 and 3·3 and are not true to parents.

Out of three F_3 families tested, one breeds quite true.

Value of F_2 plant	Value of F_3 family	Value of F_3 plant selected for F_4	Behaviour of F_4 family.
X.			
4·0	4·0	3·8 4·0 4·2	These give from 3·98 to 4·02, thus practically breeding true.
		The one F_3 family tested breeds quite true.	
XI.			
4·1	3·9	3·8 3·8 4·0	These give 3·8 and 3·9 and so breed true to F_3 family value.
		The one F_3 family tested breeds true to its F_3 family value.	
XII.			
4·2	3·99	3·9 4·1 4·4	These give from 3·8 to 3·92 and so practically breed true to F_3 family value.
		The one F_3 family tested breeds true to its F_3 family value.	

In the above summary there is strong evidence to show that parental forms can be extracted and bred true, and newer forms having intermediate values other than the parents can also be got breeding true.

This behaviour of the inheritance of mean boll loculi number, as determined above from a large number of F_3 and F_4 progeny-rows, whose parental plants of F_2 and F_3 had low, intermediate and high values of mean boll-loculi, is very important, as it will mean that out of a splitting generation of a hybrid for this character or a commercial variety of cotton containing plants of low and high values of mean boll-lock number pure strains having high value of mean boll-lock number can be easily and successfully evolved by selecting plants having high boll-lock number.

This conclusion leads to another very important conclusion of an economic character. The yield of the cotton plant which in itself is a complex dependent on the habit of the growth of the plant, the total number of effective and ripe bolls giving cotton and the locks of the bolls, the higher the number of locks of the bolls, the more the yield. Stroman [1] in his biometrical studies of lint and seed characters

[1] Stroman, G. N. Biometrical studies of lint and seed character in cotton. *Texas Agri. Expt. St. Bull.* 332 (1925).

of sixteen varieties of Texas cottons observes that all the varieties showed positive and significant co-efficients of correlation between yield of lint and yield of seed and the number of 5 and 4 locked bolls. So in order to see the difference in the yield of bolls having different lock numbers, a number of three, four and five celled bolls were picked out of Gadag I, Sea Island and the first generation of the cross. The seed-cotton of each individual boll was weighed separately, ginned and the lint and seed also weighed. The lint index and the ginning percentage were worked out and also the staple-length was measured to know if there was any difference. It was found that except for the yield of seed-cotton, and consequently of lint and seed, there was no material difference between three, four and five celled bolls in the length of staple and the ginning percentage of the seed-cotton. The following statement shows the percentage increase in the weights of seed-cotton, lint and seed in four-locked and five locked bolls over three and four locked bolls respectively in Gadag I, Sea Island and the first generation (F_1) of the cross.

Name of cotton	Percentage increase in 4-locked bolls over 3			Percentage increase in 5-locked bolls over 4		
	Seed cotton	Lint	Seed	Seed cotton	Lint	Seed
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Gadag I	42·02	29·4	7·18	7·8	2·7	1·4
Sea Island	30·95	6·6	4·8	..	..	..
F_1 of cross	31·37	10·2	1·7	2·9	0·89	1·7

From the above statement it is seen that 4-locked bolls give on an average, in the cotton studied, about 34 per cent. more seed-cotton than 3-locked bolls. It seems possible to breed a high yielding strain of cotton from among a commercial variety of cotton if selection is continued for plants having a higher percentage of 4-locked bolls, provided all other factors relating to the yield remain the same. This means that the plants selected should have high values of mean boll-lock number, which, as already seen, breeds true.

SELECTED ARTICLES

THE ARRANGEMENT OF FIELD EXPERIMENTS.*

BY

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THE PRESENT POSITION.

The present position of the art of field experimentation is one of rather special interest. For more than fifteen years the attention of agriculturists has been turned to the *errors* of field experiments. During this period, experiments of the uniformity trial type have demonstrated the magnitude and ubiquity of that class of error which cannot be ascribed to carelessness in measuring the land or weighing the produce, and which is consequently described as due to "soil heterogeneity;" much ingenuity has been expended in devising plans for the proper arrangement of the plots; and not without result, for there can be little doubt that the standard of accuracy has been materially, though very irregularly, raised. What makes the present position interesting is that it is now possible to demonstrate (*a*) that the actual position of the problem is very much more intricate than was till recently imagined but that realizing this (*b*) the problem itself becomes much more definite and (*c*) its solution correspondingly more rigorous.

The conception which has made it possible to develop a new and critical technique of plot arrangement is that an estimate of field errors derived from any particular experiment may or may not be a valid estimate, and in actual field practice is usually not a valid estimate, of the actual errors affecting the averages or differences of averages of which it is required to estimate the error.

WHEN IS A RESULT SIGNIFICANT?

What is meant by a valid estimate of error? The answer must be sought in the use to which an estimate of error is to be put. Let us imagine in the

* Reprinted from *Jour. Min. Agri.*, XXXIII, No. 6.

broadest outline the process by which a field trial, such as the testing of a material of real or supposed manurial value, is conducted. To an acre of ground the manure is applied; a second acre, sown with similar seed and treated in all other ways like the first, receives none of the manure. When the produce is weighed it is found that the acre which received the manure has yielded a crop larger indeed by, say, 10 per cent. The manure has scored a success, but the confidence with which such a result should be received by the purchasing public depends wholly upon the manner in which the experiment was carried out.

The first criticism to be answered is—" What reason is there to think that, even if no manure had been applied, the acre which actually received it would not still have given the higher yield ?" The early experimenter would have had to reply merely that he had chosen the land fairly, that he had no reason to expect one acre to be better than the other, and (possibly) that he had weighed the produce from these two acres in previous years and had never known them to differ by 10 per cent. The *last* argument alone carries any weight. It will illustrate the meaning of tests of significance if we consider for how many years the produce should have been recorded in order to make the evidence convincing.

First, if the experimenter could say that in twenty years' experience with uniform treatment the difference in favour of the acre treated with manure had never before touched 10 per cent., the evidence would have reached a point which may be called the verge of significance ; for it is convenient to draw the line at about the level at which we can say : " Either there is something in the treatment, or a coincidence has occurred such as does not occur more than once in twenty trials." This level, which we may call the 5 per cent. point, would be indicated, though very roughly, by the greatest chance deviation observed in twenty successive trials. To locate the 5 per cent. point with any accuracy we should need about 500 years' experience, for we could then, supposing no progressive changes in fertility were in progress, count out the twenty-five largest deviations and draw the line between the twenty-fifth and the twenty-sixth largest deviation. If the difference between the two acres in our experimental year exceeded this value, we should have reasonable grounds for calling the result significant.

If one in twenty does not seem high enough odds, we may, if we prefer it, draw the line at one in fifty (the 2 per cent. point), or one in a hundred (the 1 per cent. point). Personally, the writer prefers to set a low standard of significance at the 5 per cent. point, and ignore entirely all results which fail to reach this level. A scientific fact should be regarded as experimentally established only if a properly designed experiment *rarely fails* to give this level of significance. The very high odds sometimes claimed for experimental results should usually be discounted, for inaccurate methods of estimating error have far more influence than has the particular standard of significance chosen.

Since the early experimenter certainly could not have produced a record of 500 years' yields, the direct test of significance fails; nevertheless if he had only ten previous years' records he might still make out a case, if he could claim that, under uniform treatment, the difference had never come *near* to 10 per cent. His argument is now much less direct; he wishes to convince us that such an error as 10 per cent. would occur by chance in less than 5 per cent. of fair trials and he can only appeal to ten trials. On the other hand, for those ten years he knows the actual value of the error. From these he can calculate a standard error, or rather an estimate of the standard error, to which the experiment is subject; and, if the observed difference is many times greater than this standard error, he claims that it is significant. At how many times greater should he draw the line? This factor depends on the amount of experience upon which the standard error is based. If on ten values, we look in the appropriate published table for "the 5 per cent. value of t, when $n=10$" and find[1] the value 2·228. If, then, the standard error is only 3 per cent., the 5 per cent. point is at 6·684 per cent., and we can admit significance for a difference of 10 per cent.

If we thus put our trust in the theory of errors, all the calculation necessary is to find the standard error. In the simple case chosen above (in which, for simplicity, it is assumed that each of the two acres beats the other equally often) all that is necessary is to multiply each of the ten errors by itself, thus forming its square, to find the average of the ten squares and to find the square, to find the average of the ten squares and to find the square root of the average. The average of the ten squares is called the variance, and its square root is called the standard error. The procedure outlined above, relying upon the theory of errors, involves some assumptions about the nature of field errors; but these assumptions are not in fact disputed, and have been extensively verified in the examination of the results of uniformity trials.

Measurement of accuracy by replication.

It would be exceedingly inconvenient if every field trial has to be preceded by a succession of even ten uniformity trials; consequently, since the only purpose of these trials is to provide an estimate of the standard error, means have been devised for obtaining such an estimate from the actual yields of the trial year.

The method adopted is that of replication. If we had challenged, as before, the result of an experiment performed, say, ten years ago, we should not probably have been referred to the experience of previous years, but should have learnt that each trial acre was divided into, say, four separate quarters and that t e two

[1] Fisher, R. A. *Statistical Methods for Research Workers*, p. 137. (Oliver and Boyd, Edinburgh, 1925.)

acres were systematically intermingled in eight strips arranged ABBAABBA, where A is the manured portion, and B the unmanured.*

Besides affording an estimate of error such intermingling of experimental plots is of value in diminishing the actual error representing the difference in actual fertility between the two acres. For it is obvious that such differences in fertility will generally be greater in whole blocks of land widely separated, than in narrow adjacent strips. This important advantage of reducing the standard error of the experiment has often been confused with the main purpose of replication in providing an estimate of error; and, in this confusion, types of systematic arrangement have been introduced and widely employed which provide altogether false estimates of error, because the conditions, upon which a replicated experiment provides a valid estimate of error, have not been adhered to.

Errors wrongly estimated.

The error of which an estimate is required is that in the difference in yield between the area marked A and the area marked B, *i.e.*, it is an error in the difference between plots treated differently in respect of the manure tested. The *estimate* of error afforded by the replicated trial depends upon differences between plots treated alike. An estimate of error so derived will only be valid for its purpose if we make sure that, in the plot arrangement, pairs of plots treated alike are not nearer together, or further apart than, or in any other relevant way, distinguishable from pairs of plots treated differently. Now in nearly all systematic arrangements of replicated plots care is taken to put the unlike plots as close together as possible, and the like plots consequently as far apart as possible, thus introducing a flagrant violation of the conditions upon which a valid estimate is possible.

One way of making sure that a valid estimate of error will be obtained is to arrange the plots deliberately at random, so that no distinction can creep in between pairs of plots treated alike and pairs treated differently; in such a case an estimate of error, derived in the usual way from the variations of sets of plots treated alike, may be applied to test the significance of the observed difference between the averages of plots treated differently.

The estimate of error is valid, because, if we imagine a large number of different results obtained by different random arrangements, the ratio of the real to the estimated error, calculated afresh for each of these arrangements, will be actually distributed in the theoretical distribution by which the significance of the result is tested. Whereas if a group of arrangements is chosen such that the real errors in this group are on the whole less than those appropriate to random arrangements,

* This principle was employed in an experiment on the influence of weather on the effectiveness of phosphates and nitrogen alluded to by Sir John Russell (*Jour. Min. Agri.*, XXXII, 1926, pp. 989-1001). The author must disclaim all responsibility for the design of this experiment, which is, however, a good example of its class.

it has now been demonstrated that the errors, as estimated, will, in such a, group, be higher than is usual in random arrangements, and that, in consequence, within such a group, the test of significance is vitiated. It is particularly to be noted that those methods of arrangement, at which experimenters have consciously aimed, and which reduce the real errors, will appear from their (falsely) estimated standard errors to be not more but less accurate than if a random arrangement had been applied; whereas, if the experimenter is sufficiently unlucky, as must often be the case, to *increase* by his systematic arrangement the real errors, then the (falsely) estimated standard error will now be smaller, and will indicate that the experiment is not less, but more accurate. Opinions will differ as to which event is, in the long run, the more unfortunate; it is evident that in both cases quite misleading conclusions will be drawn from the experiment.

A NECESSARY DISTINCTION.

The important question will be asked at this point as to whether it is necessary in order to obtain a valid estimate of error, to give up all the advantage in accuracy to be obtained from growing plots, which it is desired to compare, as closely adjacent as possible. The answer is that it is not necessary to give up any such advantage. Two things are necessary, however: (*a*) that a sharp distinction should be drawn between those components of error which are to be eliminated in the field, and those which are not to be eliminated; and that while the elimination of the one class shall be complete, no attempt shall be made to eliminate the other; (*b*) that the statistical process of the estimation of error shall be modified so as to take account of the field arrangement, and so that the components of error actually eliminated in the field shall equally be eliminated in the statistical laboratory.

In reconciling thus the two *desiderata* of the *reduction of error* and of the *valid estimation* of error, it should be emphasized that no principle is in the smallest degree compromised. An experiment either admits of a valid estimate of error, or it does not; whether it does so, or not, depends not on the actual arrangement of plots, but only on the way in which that arrangement was arrived at. If the arrangement ABBAABBA was arrived at by writing down a succession of " sandwiches " ABBA, it does not admit of any estimate of certain validity, although " Student "[1] has shown reasons to think that by treating each " sandwich " as a unit, the uncertainties of the situation are much reduced. If, however, the same arrangement happened to occur subject to the conditions that each pair of strips shall contain an A and a B, but that which came first shall be decided by the toss of a coin, then a valid estimate may be obtained from the four differences in yield in the four pairs of strips. It is not now the " sandwiches " but the pairs of strips which provide

[1] *Biometrika*, XV, pp. 271-293, 1923.

independent units of information, and these units are double the number of the "sandwiches."

Moreover, if the experiment is repeated, either by replication on the same field, or at different farms scattered over the country, the arrangement must be obtained afresh by chance for each replication, so that in only a small and calculable proportion of cases will the sandwich arrangement be reproduced.

Thus validity of estimation can be guaranteed by appropriate methods of arrangement, and on the other hand there is reason to think that well-designed experiments, yielding a valid estimate of error, and therefore capable of genuine significance tests, will give actual errors as small as even the most ingenious of systematic arrangements. It is difficult to prove this assertion save by experimenting on the data provided by uniformity trials, because, in the absence of any satisfactory estimate of error, it is impossible to tell for certain how accurate, or inaccurate, such systematic arrangements really are; while the aggregate of the uniformity trial data, hitherto available, is scarcely adequate for any such test. What can be said for certain is, that experiments capable of genuine tests of significance can easily be designed to be very much more accurate than any experiments ordinarily conducted.

A USEFUL METHOD.

The distinction between errors eliminated in the field, and the errors which are to be carefully randomized in order to provide a valid estimate of the errors which cannot be eliminated, may be made most clear by one of the most useful and flexible types of arrangement, namely, the arrangement in "randomized blocks". Let us suppose that five different varieties are to be tested, and that it is decided to give each variety seven plots, making thirty-five in all. It would be a perfectly valid experiment to divide the land into thirty-five equal portions, *in any way one pleased*, and then to assign seven portions chosen wholly at random to each treatment. In such a case, as has been stated above, no modification is introduced in the process of estimating the standard error from the results, for no portion of the field heterogeneity has been eliminated. On most land, however, we shall obtain a smaller standard error, and consequently a more valuable experiment, if we proceed otherwise. The land is divided first into seven blocks which, for the present purpose, should be as compact as possible; each of these blocks is divided into five plots, and these are assigned in each case to the five varieties, independently, and wholly at random. If this is done, these components of soil heterogeneity which produce differences in fertility *between plots of the same block* will be completely randomized, while those components which produce differences in fertility between different blocks will be completely eliminated. In calculating an estimate of error from such an experiment, care must of course be taken to eliminate the variance due to differences between blocks, and for this purpose exact methods have been developed (*Sta. methods for res. workers*, pp. 176-232).

Most experimenters on carrying out a random assignment of plots will be shocked to find how far from equally the plots distribute themselves ; three or four plots of the same variety, for instance, may fall together at the corner where four blocks meet. This feeling affords some measure of the extent to which estimates of error are vitiated by systematic regular arrangements, for, as we have seen, if the experimenter rejects the arrangement arrived at by chance as altogether "too bad," or in other ways "cooks" the arrangement to suit his preconceived ideas, he will either (and most probably) increase the standard error as estimated from the yields ; or, if his luck or his judgment is bad, he will increase the real errors while diminishing his estimate of them.

The Latin square.

For the purpose of variety trials, and of those simple types of manurial trial in which every possible comparison is of equal importance, the problem of designing economical and effective field experiments, reduces to two main principles—(*i*) the division of the experimental area into the plots as small as possible, subject to the type of farm machinery used, and to adequate precautions against edge effect ; (*ii*) the use of arrangements which eliminate a maximum fraction of the soil heterogeneity, and yet provide a valid estimate of the residual errors. Of these arrangements, by far the most efficient, as judged by experiments upon uniformity trial data, is that which the writer has named the Latin Square.

Systematic arrangements in a square, in which the number of rows and of columns is equal to the number of varieties, such as—

A	B	C	D	E		A	B	C	D	E
E	A	B	C	D		D	E	A	B	C
D	E	A	B	C		B	C	D	E	A
C	D	E	A	B		E	A	B	C	D
B	C	D	E	A		C	D	E	A	B

have been used previously for variety trials in, for example, Ireland and Denmark ; but the term "Latin Square" should not be applied to any such systematic arrangements. The problem of the Latin Square, from which the name was borrowed, as formulated by Euler, consists in the enumeration of *every possible* arrangement subject to the conditions that each row and each column shall contain one plot of each variety. Consequently, the term Latin Square should only be applied to a process of randomization by which one is selected at random out of the total number of Latin Squares possible ; or at least, to specify the agricultural requirement more strictly, out of a number of Latin Squares in the aggregate, of which every pair of plots, not in the same row or column, belongs equally frequently to the same treatment.

The actual laboratory technique for obtaining a Latin Square of this random type, will not be of very general interest, since it differs for 5×5 and 6×6 squares, these being by far the most useful sizes. They may be obtained quite rapidly, and the Statistical Laboratory at Rothamsted is prepared to supply these, or other types of randomized arrangements, to intending experimenters ; this procedure is considered the more desirable since it is only too probable that new principles will, at their inception, be, in some detail or other, misunderstood and misapplied ; a consequence for which their originator, who has made himself responsible for explaining them, cannot be held entirely free from blame.

COMPLEX EXPERIMENTATION.

Only a minority of field experiments are of the simple type, typified by variety trials, in which all possible comparisons are of equal importance. In most experiments involving manuring or cultural treatment, the comparisons involving single factors, *e.g.*, with or without phosphate, are of far higher interest and practical importance than the much more numerous possible comparisons involving several factors. This circumstance, through a process of reasoning, which can best be illustrated by a practical example, leads to the remarkable consequence that large and complex experiments have a much higher efficiency than simple ones. No aphorism is more frequently repeated in connection with field trials, than that we must ask Nature few questions, or, ideally, one question, at a time. The writer is convinced that this view is wholly mistaken. Nature, he suggests, will best respond to a logical and carefully thought out questionnaire ; indeed, if we ask her a single question, she will often refuse to answer until some other topic has been discussed.

A good example of a complex experiment with winter oats is being carried out by Mr. Eden at Rothamsted this year, and is shown in the diagram on p. 209.

Nitrogenous manure in the form of sulphate (S), or muriate (M) of ammonia, is applied as a top dressing *early* or *late* in the season, in quantities represented by 0, 1, 2. When no manure is applied, we cannot, of course, distinguish between sulphate and chloride or between early and late applications ; nevertheless, since the general comparison 0 *versus* 1 dose is one of the important comparisons to be made, the number of plots receiving no nitrogenous manure (corresponding roughly to the so-called " control " plots of the older experiments) are made to be equal in number to those plots receiving one or two doses. This makes twelve treatments, and these are replicated in the above sketch in eight randomized blocks. Note what a " bad " distribution chance often supplies ; the chloride plots are all bunched together in the middle of the first block, while they form a solid band across the top block on the right ; in the bottom block on the right, too, all the early plots are on one side, and all the late plots on the other.

	2 M EARLY	2 S LATE		2 S LATE			1 S EARLY
1 S EARLY	1 M EARLY	1 M LATE	1 S LATE	2 M EARLY	2 M LATE	1 M EARLY	1 M LATE
	2 M LATE		2 S EARLY		1 S LATE		2 S EARLY
2 S EARLY	2 M EARLY		1 M LATE		2 S EARLY	2 S LATE	2 M LATE
	1 S LATE	1 S EARLY	1 M EARLY	1 M LATE			1 S LATE
2 M LATE		2 S LATE		2 M EARLY		1 M EARLY	1 S EARLY
2 S EARLY	2 M LATE	1 S EARLY	2 M EARLY	2 S LATE	2 S EARLY	2 M EARLY	
		1 M LATE		1 M EARLY	2 M LATE		1 M LATE
2 S LATE	1 M EARLY		1 S LATE			1 S EARLY	1 S LATE
2 M EARLY	1 M EARLY	2 M LATE	2 S LATE	1 S EARLY			1 S LATE
1 S LATE			1 M LATE	1 M EARLY	2 S EARLY	2 M LATE	
1 S EARLY		2 S EARLY			2 M EARLY	2 S LATE	1 M LATE

The value of such large and complex experiments is that all necessary comparisons can be made with known and with, probably, high accuracy ; any general difference between suplhate and chloride, between early and late application, or ascribable to quantity of nitrogenous manure, can be based on thirty-two comparisons, each of which is affected only by such soil heterogeneity as exists between plots in the same block. To make these three sets of comparisons only, with the

same accuracy, by single question methods, would require 224 plots, against our 96 ; but in addition many other comparisons can also be made with equal accuracy, for all combinations of the factors concerned have been explored. Most important of all, the conclusions drawn from the single-factor comparisons will be given, by the variation of non-essenital conditions, a very much wider inductive basis than could be obtained, by single question methods, without extensive repetitions of the experiment.

In the above instance no possible interaction of the factors is disregarded ; in other cases it will sometimes be advantageous deliberately to sacrifice all possibility of obtaining information on some points, these being believed confidently to be unimportant, and thus to increase the accuracy attainable on questions of greater moment. The comparisons to be sacrificed will be deliberately confounded with certain elements of the soil heterogeneity, and with them eliminated. Some additional care should, however, be taken in reporting and explaining the results of such experiments.

THE HIGHER AGRICULTURAL EDUCATION OF THE FUTURE.*

BY

EM. MARCHAL,

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NEARLY every country in the world possesses at the present time a system of higher agricultural education representing in each case the most advanced stage of specialized instruction.

The actual rôle of this form of education as well as the question of organization are the subjects of much controversy. Consequently unless active measures are taken without delay, it appears that agricultural education in certain countries is faced with a serious crisis. It seems, therefore, desirable to determine clearly the ends which should be pursued in these higher studies, so that they may be brought into line with the present general requirements of agriculture.

To judge from prevalent opinion, particularly as shown in Belgium, two opposing points of view are expressed in the quarters most closely concerned. Higher agricultural education as at present organized has been accused of being too theoretical so that the student is not kept sufficiently in touch with the realities of practical work. For example, it is stated that " the training provided at the agricultural colleges is much too scientific ; it inspires the farmers' sons with too progressive scientific aspirations, and instead of preparing them for rural life tends to alienate them from work on land ".

For those who hold this opinion, the ideal function of these colleges is to give careful theoretical and practical instruction in the most approved cultural methods to students preferably themselves originating from the classes directly interested in the cultivation of the soil and thus to train practical scientific agriculturists, who will in the future, by their example and influence, stand out as leaders in agricultural progress.

This desire to attract students from the country districts leads to the following characteristics in the arrangement of the programme of study :—Comparatively easy conditions of entry, limited duration of the course, a constant effort to give a practical bias to all the branches of instruction (including the basic sciences),

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the predominance of practical work on the farm and in the fields, over laboratory and lecture work.

The contrary theory is represented by those who consider that the function of higher agricultural education is not only to train students who will disseminate the knowledge of the progress already attained, but also, and more especially, to prepare pioneers, research workers, and the moulders of future agricultural progress. With this object in view, the course at the agricultural colleges, leaving aside all questions of professional training, should develop still further the scientific side and definitely take their place amongst the recognized higher university studies.

The writer during a long professional career has become convinced that agricultural education can best serve the special interests of argicultural science and the general interests of society by following the latter course.

The history of the great discoveries, which during the last fifty years have brought about the transformation of the art of cultivating the soil, hitherto in its rudimentary and empirical stage, into a complex and scientific industry, shows at each step the marks of the direct influence of pure science. Similarly the discoveries made by chemists and physiologists in their laboratories towards the end of the last century have resulted in the establishment of fundamental laws which determine animal and plant production, while purely abstract biological theories are being utilized at the present time as a basis for experimental work for still further enhancing the productivity of the soil. It is certain that the patient and laborious researches of Mendel, followed up and developed by a multitude of experimentalists, are the real source of the first definite stages of actual knowledge in the mysterious realm of heredity. Through the mutation theory of De Vries, and the pure line selection theory of Johanssen, the Mendelian theory of heredity, still further confirmed as it has been by recent cytological research, is dominant in the field of genetics, that most fruitful branch of biology, without which animal and plant breeding would be the merest empiricism.

Viewed from another standpoint it must also be acknowledged that the purely theoretical work of the mycologists and entomologists, by the light that it has thrown on the evolution of parasites in all its most minute details, has led to the establishment of a scientific basis for the methods of control of plant diseases and pests. Lastly, the peculiarly delicate investigations of bacteriologists and biologists have already begun to throw a certain light on soil microbian life and are opening up a prospect of interesting and profitable applications.

Everywhere and always, pure science constitutes the active source from which, although often it may be by long and devious paths, true practical progress is surely derived. The first stages in this development are multiple. The theory itself is almost invariably the work of scientists which is in no way concerned with the utilitarian aspect of the research work on which they are engaged. It is the affair of less original minds, with a more practical bias, to grasp its possible bearing as regards practical application. Then comes the testing of the new theory, and

the stage of practical experiment and finally the general diffusion of the newly acquired knowledge amongst those to whom it is of importance.

However this may be, in any attempt to determine the part played by teaching institutions and research in furthering the great work of scientific reform of agriculture, it must be admitted that the aim should be, pre-eminently, to secure the necessary liaison between pure theoretical science and practice, and to select from among the original abstract theories of laboratory experts, the ideas that lend themselves to practical application, testing and adapting them to the actual requirements of agricultural technique, and, finally and above all, to arrange for their general diffusion. The creative side of such institutions, although entailing much expenditure of time and energy, has been regarded, as a general rule, as of relatively minor importance.

The reason for this situation is to be found chiefly in the method of recruiting professors and research workers, as it is too often the case that less importance is given to high scientific qualifications than to technical skill on the "practical" side, without which, so it is said, any branch of science, however far-reaching, often remains sterile in the sphere of application.

The result is that too often the duly qualified leaders of agricultural progress are not, owing to their lack of sufficient scientific training, fit to undertake original research even under favourable conditions. No other result could well be expected, seeing that the nursery where they were trained and whence they are often far too exclusively recruited, *i.e.*, the institution for higher agricultural education, is often marred by the same fundamental defect.

On the contrary, the march of agricultural progress might be made far more rapid and sure, and much of the labour, expense and trouble of testing and trials might be avoided if our agricultural scientists were given a superior equipment of pure science and could go direct to the original sources of the great discoveries for the maintenance of their activities.

Surveying the great problem in the light of their practical knowledge, and directing from the outset the resulting theories towards practical applications, they would cause science to become, in the applied sphere, even more highly productive.

In the writer's opinion, the most urgent need of to-day is rather for true scientists, competent to achieve success in original research, rather than for able technicians or merely popular lecturers. The responsibility of training such men lies with higher agricultural education, but if the work is to be adequately accomplished, higher agricultural education must develop and improve its method and organization in, at any rate, many countries.

If the ideal scheme for training such highly qualified advisers on agricultural science and practice be considered, it will be seen that the course may be divided into two sections: a general scientific preparatory training and professional instruction proper. The first owing to its specially comprehensive nature is the out-

standing characteristic of agricultural instruction ; briefly it includes the various branches of mathematical, physico-chemical, mineral and biological sciences.

In each of these fields, it may be considered that the agricultural student should receive a training in no way inferior either in range or standard to that required for a degree in pure science. In the writer's opinion the bias in the direction of " practical application ", which is so often abused in the methods of scientific teaching preliminary to specialization, constitutes a serious danger, as it tends, under the pretext that they are abstract and devoid of any practical interest, to the sometimes almost complete neglect of entire sections of science, such as might ultimately be found to provide a source of important practical applications. Such a theory tends to encourage imperfectly qualified students with a limited horizon and sphere of interest, who will always be incapable of carrying out original research to advantage.

The university with its great thinkers and vast and precious teaching resources is undoubtedly the most favourable milieu for the purely scientific training of the agricultural scientists of the future.

It should not be difficult, by means of judicious interchanges in the programmes of the different faculties, to establish an ideal form of complete preliminary instruction, leading up to the special agricultural studies.

The agricultural scientist of the future in the next stages of his training course would thus be enabled to build up his purely professional instruction on the solid foundations of the sciences in general. It is at this stage only that the professional faculty or, in other words, the higher agricultural institute enters into the field. Situated in the country and in rural surroundings, where at every point the instruction can be refreshed and invigorated by practical demonstration, the institute with its experiment farm, its research stations staffed with eminent scientists should prove a focus of applied science in direct and constant touch with the great general intellectual centre provided by the university town from which, consequently, it should not be too far distant.

The organization of the programmes of study and the method followed at this institute will not be inspired by the essentially abstract conceptions of pure theory, but the far more tangible and living requirements of science applied to practice.

In order, however, to safeguard, from the point of view of its specialized character, the type of education which is required, various dangers must be avoided. In certain special schools, though classed as of the " higher " rank, there is a tendency to make the professional instruction degenerate into a kind of technical initiation into the practice of such and such a branch of agricultural industry or speculation. Under the guise of exercises in the adaptation of theory to practice, the student is required to carry out processes and manual operations which could be far better learnt after the completion of his studies during the course of the stage which every student should pass through before starting on his professional career.

The subject of practical application in higher professional instruction should take the form of training the student how to observe, measure and analyse, to complete his knowledge by means of documentation, and to initiate him into experimental method and individual research. Such studies, it may be added, should tend to occupy an increasingly important position in the time-table as their teaching value is inestimable. It is pre-eminently in the study of practical applications and tutorial work that the professor will find his chief opportunity for acting as initiator and revealer; it is at the point of contact of theory with fact that he will best be able to show his mastery and acquire that moral ascendency that will make his pupil respect and honour in his person both science and professional ability. This is also the stage when he can most readily inspire the student with the love for research and the method to be pursued, by arousing his curiosity either in the progress and results of his special work or in other subjects equally capable of serving as a basis for original study. In short, the sphere of practical applications will give the professor the means of establishing on more solid bases than those of an examination, a sound appreciation of the value and real knowledge of a student.

For the student himself, the practical exercises will provide the opportunity of obtaining the most solid and lasting form of knowledge, of developing his spirit of initiative and testing his capacities and of gauging personally his degree of attainment. But, as already stated, the object of demonstration work and practical exercises must remain always at a high standard, as the period which the student can devote to his higher studies is too precious to be spent in carrying out work of a purely technical nature.

Another danger to be avoided in the higher agricultural course is in the writer's opinion the tendency towards an exaggerated specialization. Agriculture viewed as a whole, undoubtedly, occupies too vast a field to allow any individual to make a complete scientific study of all its branches. The agriculture of temperate and tropical countries respectively, forestry, horticulture, live-stock, chemistry, technology, and farm engineering, all form special branches of which an intensive study can be made with the object of training special classes of scientific agriculturists.

It is necessary, however, to safeguard the general agricultural training which an extreme specialization would jeopardise and to avoid turning out men with an incomplete equipment, who although well-trained in the minutest details of some particular branch, remain, owing to their insufficient knowledge of general methods and broad principles, incapable of seeing, understanding and adapting themselves to what takes place outside the narrow limits of their own accustomed sphere of activity.

A high level of preliminary scientific education, a far-reaching general professional training and a moderate degree of specialization, such should, according to the views of the writer, be the qualifications which the agricultural scientist of to-morrow should be expected to supply.

It should be at once admitted that at present such a programme is already, at any rate in its essential lines, being carried out in several countries. Such countries have realized that the day of a relatively easy victory and diffusion of knowledge is ended, and that for wresting from Nature the secret of new wealth and for realizing the imperious claims of impoverished humanity in this troubled post-war period for an increase in the productivity of the soil, an ever increasingly urgent appeal must be made to the aid of science as the only true generating force of progress.

NOTES

ASIATIC-AMERICAN COTTON HYBRIDS.

In "The Agricultural Journal of India," for November 1926, a translation was given of a paper originally published in the "Transactions of the Turkestan Plant Breeding Station," Tashkent, by Dr. G. S. Zaitzev on hybrids between Asiatic and American plants. The Director of the station, Dr. Zaitzev, now has very kindly furnished a paper in English on his work which he has brought up to date to November 1926; the results obtained cannot fail to be of interest to cotton botanists in India. The possibility of obtaining a hybrid between the American and Asiatic types of cotton has always attracted cotton workers, mainly because the maximum length of staple of any known Asiatic type is so much below that of Egyptian and Sea Island cottons which belong to the American group. Dr. Zaitzev has obtained such hybrids both by artificial and natural cross-fertilization, but all the hybrids have proved to be completely sterile and are thus of no economic importance. The existence of natural, though sterile, hybrids described for the first time in the present paper is exceedingly suggestive. In a paper[1] by Denham the chromosome numbers of various types of cotton are stated and the chromosome number for the American group is double that of the Asiatic. Though Denham's work on Asiatic types was not exhaustive it affords an explanation why no viable hybrid has ever been obtained. In the same paper the author points out the possibility of individual plants of Asiatic types occurring occasionally with double the usual number of chromosomes, and suggests that this may permit of the formation of occasional fertile hybrids. The apparent comparative freedom with which inter-species hybrids occur in Turkestan is hence of no small interest.

An important feature of the paper is the very full description given both of the parental plants and of the hybrid, which show that hybrids were in fact obtained. Incidentally the careful descriptions of Turkestan varieties of *G. hirsutum* and *G. herbaceum* have an interest of their own. [B. C. Burt.]

ECONOMICS OF MANURING RICE WITH SULPHATE OF AMMONIA.

In the present note an attempt has been made to utilize the results obtained at the Karjat Rice Research Station, Bombay, to ascertain to what extent field manuring of rice with sulphate of ammonia has proved itself profitable. The method is that used by Anstead and described in "The Agricultural Journal of India", Volume XVIII, page 534, and the results are based on the combined figures of yield obtained from duplicate series in the year 1923, taken in connection with the prices of sulphate of ammonia in 1923 and in 1925.

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[1] *Shirley Inst. Mem.*, Vol. III, No. 21 (1923).
Jour. Tex. Inst., Vol. 15, 1924, T. 496-500.

In these experiments quantities of the fertilizer yielding varying amounts of nitrogen from 40 to 100 lb. per acre were applied to plots growing a pure type of Kolamba rice. The price of paddy was taken as 20 lb. per rupee throughout. The price of suplhate of ammonia was Rs. 30 per bag (of 200 lb.) in 1923, and Rs. 22½ per bag in 1925.

The actual results obtained are shown in the following tables :—

TABLE I.

Yield and profits of rice dressed with sulphate of ammonia at prices of 1923.

Plot	Sulphate of ammonia added per acre	Yield of rough rice per acre	Value of produce per acre	Cost of production per acre	Profit per acre	Increment of cost per acre	Increment of profit per acre
	lb.	lb.	Rs.	Rs.	Rs.	Rs.	Rs.
1	nil	2,460	123	35	88	..	..
2	200	4,150	207	65	142	30	54
3	300	4,574	228	80	148	45	60
4	400	4,618	231	95	136	60	48
5	450	4,625	231	102½	129	67½	41
6	500	4,412	223	110	113	75	25

These results are set out graphically in Fig. 1. Here quite clearly the cost of production rises almost uniformly. On the other hand the profits which rise steeply

1923.

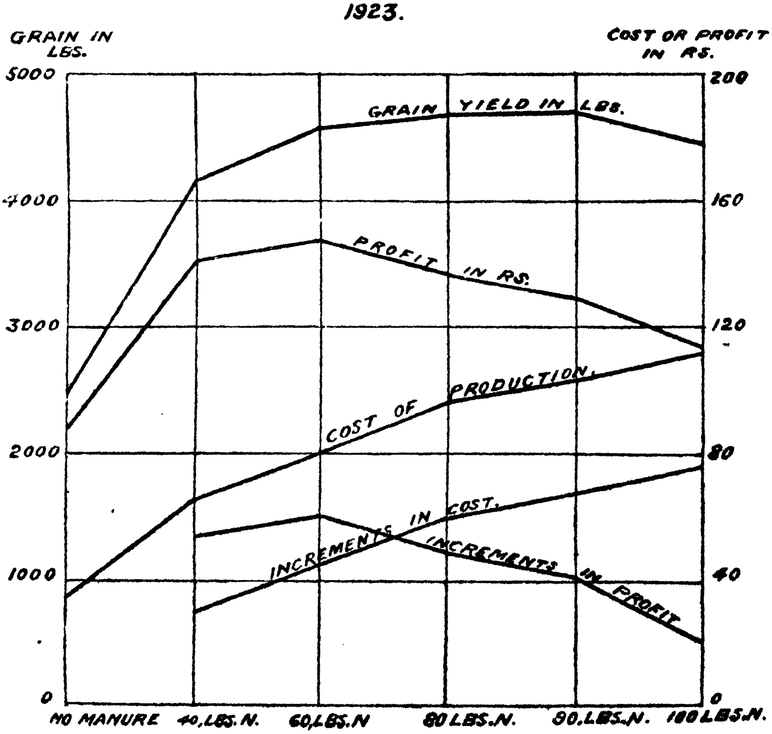

FIG. 1.

for the first application of 200 lb. of sulphate of ammonia (equal to 40 lb. nitrogen) per acre, begin to flatten from this point, and after the addition of 300 lb. of the fertilizer per acre, the actual profit becomes less. This is even clearer if the successive *increments* in cost of production and of profit are plotted. This has been done on the attached diagram, from which it is evident that the increments in cost steadily exceeded the increments in profit after the addition of 300 lb. of sulphate of ammonia (Fig. 1).

TABLE II.

Yield and profits of rice dressed with sulphate of ammonia at prices of 1925.

Plot	Sulphate of ammonia added per acre	Yield of rough rice per acre	Value of produce per acre	Cost of production per acre	Profit per acre	Increment of cost per acre	Increment of profit per acre
	lb.	lb.	Rs.	Rs.	Rs.	Rs.	Rs.
1	nil	2,460	123	35	88	..	..
2	200	4,150	207	57½	149½	22½	61½
3	300	4,574	228	69	159	34	71
4	400	4,618	231	80	151	45	63
5	450	4,625	231	86	145½	52	56½
6	500	4,412	223	92½	130½	57½	42½

These results are set out graphically in Fig. 2. Even at the price of 1925 (which

1925.

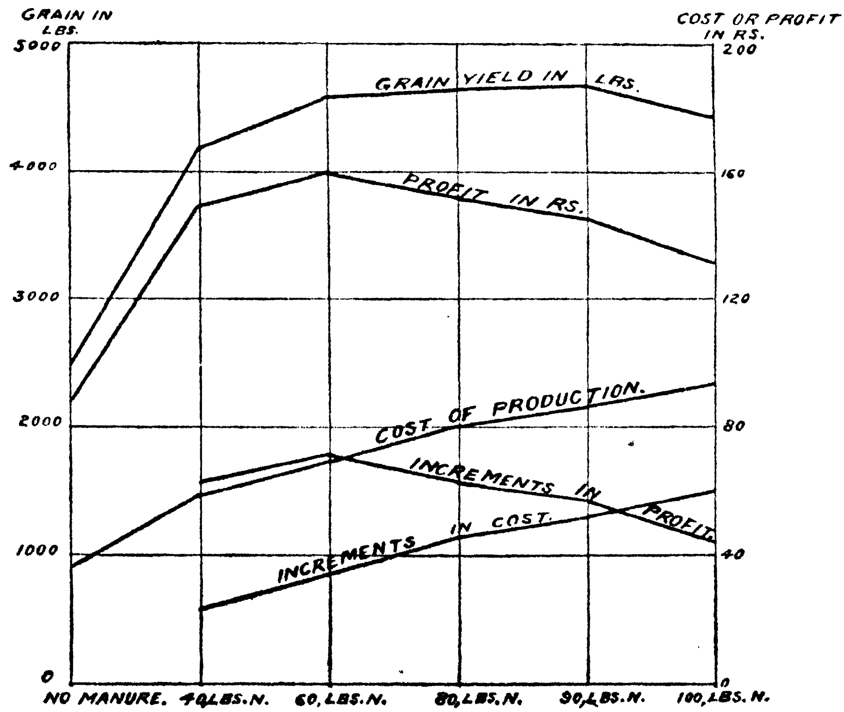

FIG. 2.

is only 75 per cent. of that of 1923) the limit of profitable application of sulphate of ammonia is still 300 lb. of sulphate of ammonia (equal to 60 lb. nitrogen) per acre. But while even at the present price no greater application would be justified, yet it can easily be seen that a further reduction in the cost of sulphate of ammonia (which is so far the most effective nitrogenous manure used for rice in the North Konkan) would justify a larger use and hence a greater yield from the land. [D. M. KULKARNI.]

SUGARCANE IN JAMAICA.

THE Annual Report of the Department of Agriculture, Jamaica, for the year 1925, gives an interesting account of the work done in connection with the sugar industry of that island. The report states that throughout the year agricultural conditions were generally favourable. There was an increase of 15,000 tons in the quantity of sugar exported in 1925 as compared with 1924, when it was only 23,000 tons.

A noteworthy event of the year in the sugar history of Jamaica was the erection of a sugar factory in St. Thomas. Remarkable results were obtained in the rapid development of cane cultivation in the area surrounding the factory. This is in conformity with what we have observed on this side of India also.

It is satisfactory, states the Superintendent of Agriculture, Jamaica, in his observations on mosaic disease that the position as it existed in December 1924 has been in the majority of cases maintained, in that the disease has not increased, and is under control and does not seriously affect the output of sugar. This, however, has only been done by vigorous and continual rogueing and in some cases at considerable expense. Where rogueing has not been found efficient in the control of the disease due to its rapid and extensive spread, resort has been made to the Uba cane which fortunately for several estates has been found to do well. Planters were kept alive to the necessity of continual and vigorous measures for the control of mosaic, for if neglected even for a short time all work done and success gained would immediately be lost. The growing of the Uba cane by the small settlers forms now an important problem for solution by the department as only with an immune cane can the mosaic disease be overcome in this direction. The report states that it is difficult to get the small cane-grower to recognize mosaic disease and still more difficult to get him to rogue his fields. The solution here is an immune cane, and Uba is being introduced wherever there is the slightest encouragement for doing so.

To determine the sugar yield per acre of the various seedling canes, experiments were conducted on 11 estates. Of the 22 selected varieties tested during the year, the seedling B. S. F. (12) gave 52 tons per acre as a first ratoon which was 17 tons per acre more than the Bourbon cane growing beside it. B. 178, B. 205, B.

261, B. S. F. 1248 all gave better results than the Bourbon. The B. H. 10 (12) is rapidly assuming an important position in the cane cultivation of the island.

The Uba variety has proved its worth as an emergency cane in cases of widespread attack of mosaic and as a good cane for poor stiff lands where other canes will not grow. B. H. 10 (12) is a heavy producer with higher sugar value, suitable for good conditions, while Ba 11569 has proved beneficial on good soil with poor rain and no irrigation.

In the report an interesting point is brought out by Mr. Hansford, the microbiologist, as a result of the observations made during the last two years, *viz.*, that the 'fall plants' are not attacked to the same extent as the 'spring plants'. This is also the case in Cuba. Thus by planting new fields only in the fall of the year one can reduce the proportion of canes to be rogued out on account of mosaic infection.

As regards the part played by insects in the transmission of mosaic disease the following paragraph taken from the report of the microbiologist, Mr. Hansford, will be read with interest :—" At the commencement of the year experiments were carried out with *Aphis maidis* as a vector of the disease. The results proved that this insect was capable of transmitting the disease from corn to cane and from cane to cane. At the same time it must be admitted that sugarcane is not a natural host of this aphis, which prefers other plants such as corn and Guinea corn. There is a great discrepancy between the laboratory results with insect vectors of this disease and field experience. In the laboratory it is difficult to get this aphis to transmit the disease from plant to plant, yet in the field, under certain conditions not at present well understood, the disease spreads in a wholesale manner. Yet *A. maidis* is still the only insect definitely proved a carrier of this disease, though certain other insects have been reported from time to time, but on insufficient grounds. These have not yet been confirmed as carriers, and are only under suspicion at the moment." [K. D. NAIK.]

VITAMIN B.

RECENT experimental work by V. G. Heller, C. H. McElroy and Bertha Garlock of the Oklahoma Agricultural and Medical College at Stillwater, to be reported in *The Journal of Biological Chemistry*, indicates that a spore-forming organism found in the intestinal tract causes a building up and storing of vitamin B which is necessary for growth and proper development.

In carrying out the experimental work, white rats were fed on a diet of food known not to contain vitamin B. Previous experiments had shown that rats fed on this vitamin B-free diet continued to grow and exhibited symptoms of vitamin B deficiency only very slowly. It was soon found that where the rats had the opportunity to reingest some of the excretion from the intestine, the effects of the

dificient diet were very slow. The cages of the rats were then arranged so that the animals would not have access to the intestinal excretion, and soon the animals began to show signs of vitamin B deficiency, their growth was retarded and death followed.

A culture of the spore-forming organism was then made and this was incorporated with their food. Almost at once the symptoms of vitamin lack disappeared, the growth of the rats returned to the normal rate and they began to thrive again. As a later refinement it was found that the addition of roughage in some form to the diet to increase the bulk of food in the intestine aided the process in the intestine whereby vitamin B is built up and stored by means of the spore-forming organism. [*Science,* N. S., No. 1600.]

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

SEA ISLAND COTTON.

Lint length and rainfall. Variations in the maximum lint length of a pure strain of cotton may be ascribed to variations in environment, and those changes which occur from day to day may be regarded as due to changes in the climatic conditions. The critical period in determining lint length was found in Egypt and St. Kitts about nineteen days after flowering, and in the latter heavy rainfall during the critical period was found to increase the length of the lint. This latter result is the converse to the effect of heavy rains in St. Vincent, where as much as 3·7 mm. reduction in staple length was observed. The explanation lies in the fact that the average 45 inches of rainfall in St. Kitts is on the short side for Sea Island cotton, and a relatively heavy rainfall produces an improvement in conditions. In St. Vincent with the average rainfall of 100 inches, the water supply is seldom deficient and the conditions are normally humid. The periods of heaviest rainfall produce water-logged soils and other adverse effects, to the consequent depreciation of the lint length. If the cause and the depreciation prove general, it should be possible to predict the depreciation in lint length by about thirty days, and thus to facilitate grading.

Spacing experiments. Optimum spacing appears to be 17 inches at one plant per hole. 19 inches with two plants a hole, and at 18 inches it appears to be immaterial whether one or two plants are left in each hole. At all spacings wider than 19 inches the two per hole series gives a greater yield, and the wider the spacing the greater

the superiority. As the superiority of the two per hole series is greater, the earlier in the season the comparison is made, where there is any danger of a loss of bolls at the end of the season, it would be wisest to leave two plants to each hole. Below 16 inches spacing the yield is reduced.

The marginal effect in plot experiments. The results derived from the spacing experiments show marginal effects, which are dependent on the maximum root range of the plant. From these results it was calculated that the lateral range of the roots should extend to 6 or 7 feet; and this was verified by actual measurement. The exclusion of only the outside plants, in plot experiments on Sea Island, is therefore inadequate for the exclusion of marginal errors. All plants nearer to the margin than 7 feet should be discarded. [*Empire Cotton Growing Review*, 1925, **2**, 225-236, L. H. BURD.]

COTTON BOLL.

Boll studies at the Louisiana Experiment Station gave indications of the importance of protecting boll setting while blooming is increasing to its maximum, and that weevil control after this maximum is reached is relatively less improtant, so far as maturity of the crop is concerned. The rainfall recorded did not seem to affect boll setting injuriously. Plants spaced 8-12 inches apart averaged 30 or more bolls per row foot, whereas those spaced 20 to 30 inches apart produced only 11 bolls per row foot. [*Expt. Sta. Rec.*, 1925; **53**, 528; from *Louisiana Sta. Rept* 1924, pp. 12 etc. A. F. KIDDER and others.]

CONTROL OF BOLL WEEVIL.

The losses sustained by the American cotton crops of 1921 and 1922 as a result of attack by boll weevil were estimated at about £200,000,000. The American Cotton Association, therefore, undertook the leadership of a general campaign, as a result of which 933 cotton demonstration farms of 10 acres were established in 1923. The growers were responsible for the success of the control measures, applied under simple and practical instructions. Many letters indicating the success of the campaign are quoted. In one of these it is stated that four good applications of calcium arsenate will result in a bale of cotton per acre on good land under heavy weevil infestation. Using poison, 1,250 lb. of seed-cotton per acre was obtained as compared with 700 lb. from the same type of land without poison. It has been proved conclusively that the plan of culture and weevil control as applied under the supervision of the Association increases the yield per acre by one-third. If the work could be extended to all the infested counties the weevil would soon be definitely controlled. [*Rev. Appld. Entomol.*, 1925, **13**, Series A, 635; from *Handbook of American Cotton Association—Boll Weevil Control Campaign—Season* 1924-1925, 32 pp.]

LIFE-HISTORY OF COTTON APHID.

Experiments conducted with species of the cotton aphid, *Aphis gossypii*, indi cate the possibility that the winter host of this pest is the orpine plant, *Sedum telephium*. [*Science*, 1925, **62**, 510. E. M. PATCH.]

COTTON PESTS OF THE EAST.

The insect pests of cotton occurring in Egypt, India and Mesopotamia are reviewed. The Russian cotton fields are comparatively free from any serious pests and the importance of maintaining these conditions is emphasized. [*Rev. Appld. Entomol.*, 1925, **13**, Series A, 598 ; from *Cotton Industry, Moscow*, 1924, **3**, 63-77. B. P. UVAROV.]

COTTON PESTS OF SOUTH AFRICA.

A brief review of the insect pests of cotton in South Africa. Nearly 200 insects are concerned but the author deals only with the most important ones. The bollworms *Diparopsis castanea*, *Earias insulana*, *Heliothis* (*chloridea*) *obsoleta* and *Pyroderces simplex* are the most serious pests. Soil drainage and local conditions appear to be factors influencing the cotton Jassid, *Empoasca* (*chlorita*) *facialis*. The only effective way to deal with soil pests attacking field crops is to maintain a close or dead season, preferably for two months or more each winter. Boll-shedding should be thoroughly studied in connection with the study of the different pests, especially bollworms and plant bugs. The most urgent problem is to find effective and practical remedies for the bollworms. A Jassid-resistant cotton is in course of development. In the author's opinion, cotton insect control is not entirely an entomological matter but concerns agricultural practices and plant selection studies and is influenced by climatic conditions. The value of ratooning is still debatable. Serious consideration should be given to the possibility of growin other crops and of mixed farming, *e.g.*, live stock and field crops. [*Rev. Appld. Entomol.*, 1925, **13**, Series A, 615 ; from *Jour. Dept. Agri. Union South Africa*, 1925, **11**, 361-365. G. C. HAINES.]

RELATION OF WALL THICKNESS TO DYEING OF COTTON HAIR.

Differences in shade of two bleached cottons of different growths or varieties when dyed together in the same bath cannot be ascribed to chemical differences in the bleached cottons but must be due to some characteristic variation from growth to growth in the structure of the individual hairs. In particular, it is found for certain growths that the order of shade in simultaneous dyeings is identical with the order of wall thickness of the hairs as measured by the hair weight per centimetre length, the fine Sea Island and Egyptian Sakel cottons dyeing the lightest and the coarser American and Indian cottons the darkest shades. It is not inferred that the

wall thickness is the only structural feature affecting the dyeing shade, but it is at least a good qualitative guide in predicting the comparative dyeing behaviour of two or more cottons. The correlation obtains for all types of dyestuft examined—direct, sulphur and vat. An extreme case is that of the abnormally thin-walled immature or " dead " cotton, which dyes a very light shade when compared with mature cotton in the same dyebath. Some observations are recorded on the effects in subsequent dyeing of varying the twist of a yarn and on varying the pressure at which the yarn is kier-boiled. [*Jour. Text. Inst.*, 1925, **16**, T. 305-310. D. A. CLIBBENS and B. P. RIDGE.]

COTTON STAPLE STANDARDS.

It has been decided to issue practical forms for seventeen lengths of staple in American Upland cotton, varying from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches and four lengths of American Egyptian cotton, varying from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches. The range now includes types not previously represented. [*Text. Mercury*, 1925, **73**, 356.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. F. NOYCE, C.S.I., C.B.E., I.C.S., has been appointed Attached Officer, Royal Commission on Agriculture in India, with effect from 5th February, 1927.

ON completion of his special duty as Secretary to the Indian Delegation to South Africa, Mr. G. S. Bajpai, C.I.E., C.B.E., I.C.S., resumed charge of the office of Deputy Secretary to the Government of India in the Department of Education, Health and Lands, with effect from 19th February, 1927. The services of Mr. R. B. Ewbank, C.I.E., I.C.S., have been replaced at the disposal of the Government of Bombay.

MR. A. B. REID, I.C.S., has been appointed Additional Deputy Secretary to the Government of India in the Department of Education, Health and Lands, from 9th April, 1927.

RAO SAHIB M. R. RAMASWAMI SIVAN, B.A., Dip. Agri., Government Lecturing Chemist, has been appointed Principal, Agricultural College, Coimbatore.

MR. SAADAT-UL-LAH KHAN, M.A., B.Sc., Professor of Agriculture and Superintendent, Central Farm, Coimbatore, has been granted leave for six months from 1st March, 1927.

MR. D. BALAKRISHNAMURTI GARU, Deputy Director of Agriculture, has been appointed Professor of Agriculture and Superintendent, Central Farm, Coimbatore, *vice* Mr. Saadat-ul-lah Khan granted leave.

MR. T. J. HURLEY, M.R.C.V.S., Officer in charge of IV Circle, Civil Veterinary Department, Madras, has been granted combined leave for 15 months from 5th April, 1927.

BABU KRISHNA SWARUP has been appointed to officiate as 3rd Agricultural Engineer, United Provinces, *vice* Mr. R. S. Hobson granted leave outside India.

RAI SAHIB LALA JAI CHAND LUTHRA, M.A., Associate Professor of Botany, Punjab Agricultural College, Lyallpur, has been confirmed in the Indian Agricultural Service.

MR. F. B. HARROP has been appointed Poultry Expert to Government, Punjab, with headquarters at Lahore.

MR. H. R. STEWART, A.R.C.Sc.I., Professor of Agriculture, and Mr. T. W. R. Easton, Executive Engineer, Lift Irrigation, have been appointed Officiating Principal, Punjab Agricultural College, and Officiating Agricultural Engineer to Government, Punjab, respectively, in addition to their own duties, from 22nd March, 1927, *vice* Mr. T. A. Miller Brownlie granted leave for eight months.

MR. J. F. SHIRLAW, M.R.C.V.S., has been appointed Professor of Pathology at the Punjab Veterinary College, Lahore, for a period of three years from 3rd April, 1927.

MR. T. J. EGAN, M.R.C.V.S., Superintendent, Civil Veterinary Department, North Punjab Circle and North-West Frontier Province, has been granted leave for eight months from 30th March, 1927, Mr. Syed M.A. Shah Gilani being placed in charge of the current duties of the post.

MR. T. D. STOCK, B.Sc., A.R.C.S. Officer on Special Duty in the Office of Director of Agriculture, Burma, has been granted leave for eight months from 24th March, 1927.

MR. D. RHIND, B.Sc., Mycologist to the Government of Burma, has been granted leave on average pay for eight months from 22nd March, 1927.

CAPTAIN S. R. RIPPON, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, has been confirmed in his appointment in the Indian Veterinary Service from 18th February, 1927.

MR. E. A H. CHURCHILL, B.Sc., Assistant Director of Agriculture, Northern Circle, Central Provinces, has been granted leave for eight months from 8th April, 1927.

MR. W. Harris, M.R.C.V.S., Superintendent, Civil Veterinary Department, Assam, has been allowed leave for eight months from 1st May, 1927.

REVIEWS

The Insects of Australia and New Zealand.—BY R. J. TILLYARD. (ANGUS AND ROBERTSON, SYDNEY : 1926 : large 8vo, pp. xv+560, 44 Plates [of which 8 are coloured], 468 text-figures.) Price, 42*s*.

This useful and well-written book on the Insects of Australia and New Zealand has been produced by Dr. R. J. Tillyard, of the Cawthron Institute, N.Z., whose work, especially on Dragonflies and on Fossil Insects, is well-known to all entomologists.

The first chapter deals briefly with the Classification of existing Insects, which are here divided into twenty-four Orders, and the author estimates that some 470,090 Insects are now known from the whole World, of which 37,080 species occur in Australia and 8,150 in New Zealand. It may be noted that the numbers of described species at present known from Australia and from India are roughly the same. The second and third Chapters deal briefly with the External and Internal Morphology of Insects and Chapter IV with Life-history, and thereafter we have a series of Chapters (V-XXVIII), each devoted to one Order. Each of these Chapters contains a very useful key (or keys) to the Families dealt with in it, besides general remarks on ordinal characters, life-histories, distribution and economics. Under each Family are given the characters and other general remarks and a necessarily condensed account of representative genera and species. Chapter XXIX deals with the Fossil Record and the Origin of the Australian and New Zealand Insect Faunas, and Chapter XXX with the Collection, Preservation and Study of Insects. Finally, we have a useful Glossary of terms and a full Index.

Although very few of the species of Insects here referred to are also Indian, the amount of information, which will be of use to the entomological worker in India, is very large and we can cordially recommend this book to all such.

The illustrations are particularly good and are almost all new. The whole book reflects great credit on its Author and Publishers and will prove a joy to all Entomologists. [T. B. F.]

The Breaking of Yarns and Single Cotton Hairs.—BY GLADYS G. CLEGG. *Journal of the Textile Institute*, XVII, 1926, T. 591.

Why does a cotton yarn break when submitted to tension ? This simple question has always been rather a bone of contention among those interested in textile testing, so that it has not always received the same answer. At first sight one

would probably expect a yarn to break when its several fibres are unable to withstand their individual shares of the applied load. Yet this obvious explanation has by no means found universal acceptance. Owing to the fact that experimental determinations of yarn strength did not tally with those calculated from fibre strength, it has been asserted and apparently commonly believed that the fracture of yarns was the result not of the fracture of fibres but of the slippage of fibres one upon another. The present writer for various reasons could not accept this fibre-slippage theory, and from an analysis of the facts of yarn and fibre structure was able to formulate and publish early in 1920 a list of seven factors (to which shortly afterwards an eighth was added) *each* of which would tend to prevent the complete realization of fibre strength in a yarn. Their cumulative effect would be very large indeed, and the conclusion was therefore reached that from a consideration of these factors "we may explain why only 20 to 25 per cent. of the 'strength' of the fibres is realized in a yarn. The explanation generally given that this small percentage is due to a slipping of the fibres is certainly not true for hard-twisted yarns, as the study of the fractured ends of such a yarn conclusively demonstrates."

This conclusion has been completely substantiated by an ingenious experimental investigation carried out by Miss Clegg, who thereby gives the death-blow to the fibre-slippage theory. Miss Clegg shows that by means of the Congo red staining method devised by Bright it is possible easily to distinguish—

(1) The broken end of a hair.
(2) The basal end of a hair where it was torn from the seed by the gin.
(3) The cut end of a hair.
(4) The tip of a hair.
(5) The number of hairs ending naturally in a given fraction of the yarn length.

Applying the method she has counted the number of broken ends of fibres at the point of breakage and als the average number of broken ends which would naturally occur in the breakage region, so that by a process of subtraction she has been able to determine the actual number of fibres fractured when the yarn broke.

The following table shows in abstract form the results which were obtained :—

Cotton	Counts	Turns per inch	Tester	No. of broken hairs	No. of hairs in section	Per cent. of broken hairs
Sakel	36's Warp	20	Ballistic	55	83	66
,, ...	,,	20	Single Thread	59	84	70
Surat	20's Warp	..	,, ,,	37	83	45
,, ...	,,	..	,, ,,	32	78	41
Uganda Upland N. 17 .	64's Warp	20	Ballistic	30	46	65
Uganda Upland A.2 . .	,,	20	,,	33	56	59

Commenting on these results the author states that "the examples are too few and the degree of significance of the numerical results too low to permit of detailed comparisons being made. They are however sufficient to demonstrate that, in the majority of cases, yarn breakage does not take place by slipping but by actual rupture of more than half the hairs." The last phrase is hardly justified in its application to the results for Surat cotton.

The Uganda Upland cottons when tested as single yarns realized more than the 20-25 per cent. of the fibre strength referred to above—N. 17 yielding 38 per cent. and A.2 yielding 41 per cent.

The following are a few of the results for fibre strength compared with lea strength, leading to the conclusion that "no correlation is shown between yarn strength and single hair breaking load."

Cotton	Counts	Breaking load of single hairs (grm.)	Lea strength lb.
Sakel 1	80's	5·67	31·8
Sakel 2	"	4·16	30·4
Assili A/22	"	5·70	24·8
Zagora	40's	5·01	34·3
"	"	6·45	35·6

The remainder of the paper is taken up with a consideration of "the breaking load of single cotton hairs." Variously-peaked frequency curves were obtained for this quantity; their irregularity was attributed largely to the presence of abnormalities in cotton fibres; it was found in the case of Zaria cotton that out of 202 fibres examined 72 displayed some abnormality of structure. "But even when these have been allowed for (in the frequency-breaking strength curve), the curve is still far from regular." On this account Miss Clegg appears rather to doubt the value of tests of breaking loads of fibres, more especially because she considers "that abnormal or weakened hairs are not likely to occur in the same proportions in different samples of the same cotton." This statement needs a little amplification to make it clear but surely its truth or the reverse should be a matter for investigation—it can hardly be dismissed so lightly in view of its tremendous importance.

Considering the length of the test piece, Miss Clegg recommends employing "whole hairs in order to obtain the maximum chance of encountering the weakest place in each."

Lastly, some measurements are given with reference to the relation between breaking load and wall thickness of hair. "The results show that the relation

between the two quantities is not very definite. Cottons with approximately equal wall thickness may have very different breaking loads and *vice versa*. Most of the disturbance of the relation is due to the irregularity and variability of the quantity determined as breaking load, and the responsibility of the wall thickness is only a minor one, for its distribution throughout a sample of cotton is invariably regular .... Some portion of the lack of relation is no doubt due to the fact that it is the wall thickness at the actual point of rupture which is important, so that the results should, probably, not be interpreted as showing more than that the finer cottons with thinner walls do not necessarily possess low breaking strains."

If one may venture a criticism of a very valuable paper it is that the introduction is not very clear when dealing with the work of the pioneers—Monie and Bowman. The impression is rather conveyed that these early workers were adherents of the fibre-slippage theory although it is a fact that nowhere in their writings do they give explicit expression to any such view of yarn-breakage. Indeed in Bowman's case, at any rate, it would be possible to show that his ideas on the subject were really eminently sound. [A. J. T.]

Research and the Land : Recent Progress in Agricultural and Horticultural Science in the United Kingdom.—By V. E. Wilkins, B.Sc. Pp. 388; 29 illus. (London : H. M. Stationery Office.) Price, 2*s*. 6*d*.; cloth, 3*s*. 6*d*.

This book covers the whole of the agricultural and horticultural research carried out in the United Kingdom during the past four or five years. Something like £400,000 a year is now being spent by the State on this work.

The field surveyed is sufficiently indicated by the table of contents. Starting with the soil, the book describes investigations into its physics, chemistry and biology; the question of plant breeding is then dealt with, and the means by which improved varieties are introduced to commerce; the question of the living plant is then taken up, and the investigation of its physiology explained; horticulture receives separate attention, and a fairly complete summary is given of the Long Ashton, East Malling and Cheshunt investigations, and the work on fruit preservation and storage at Chipping Campden and Cambridge; finally, on the subject of plants, the numerous diseases are dealt with in detail, and a further chapter is devoted to general investigations which affect the whole field of plant disease treatment.

Turning to the animal kingdom, the book first deals with the feeding of stock, and outlines fundamental investigations on such subjects as the mineral constituents of feeding stuffs and the influence of ultra-violet rays. The scientific investigation of particular feeding stuffs, such as pasture grass, wheat offals, silage, etc., is next

dealt with. This is followed by an account of valuable work on animal reproduction and breeding. The practical research schemes into pigs and poultry are then described. Dairying research, including the question of clean milk and the investigation of manufacturing difficulties in connection with milk products, occupies the next two chapters. A further chapter outlines the work on animal diseases which is being carried out at many centres. Agricultural engineering, including crop drying work and the investigation of the new process of sugar extraction from sugar beet, is dealt with. Finally, a survey is presented of research into agricultural economics which has come so largely into the limelight since the War.

The book runs to 388 pages and includes 29 illustrations chosen to present a fair picture of the main phases of scientific investigation. There are two appendices, one containing a list of research and advisory centres throughout the United Kingdom, and the other being a complete bibliography of technical publications on agricultural and horticultural research published within the past four years. The book is fully indexed.

NEW BOOKS

On Agriculture and Allied Subjects

1. Crop and Stock Improvement, by A. B. Bruce and Dr. H. Hunter. (*The Farmer and Stockbreeder Manuals.*) Pp. 119. (London : Ernest Benn, Ltd.) Price 5*s*. net.
2. The Principles and Practice of Yield Trials, by F. L. Engledow and G. Udny Yule. Pp. 78. (London : The Empire Cotton Growing Corporation.) Price 2*s*.
3. Testing Milk and its Products, by G. Sutherland Thomson. pp. viii+83. (London : Crosby Lockwood and Son.) Price 4*s*. net.
4. The Cattle-Breeder's Handbook, by James A. Scott Watson and others. (*The Farmer and Stockbreeder Manuals.*) Pp. 144. (London : Ernest Benn, Ltd.) Price 6*s*. net.
5. Hydrogen Ion Concentration : Its significance in the Biological Sciences and Methods for its Determination. Vol. I : Principles of the Theory. Authorized translation from German edition, by William A. Perlzweiz. Pp. xiv +299. (London : Baillière, Tindall and Cox.) Price 22*s*. 6*d*. net.
6. The Scientific Feeding of Animals, by O. Kellner. Authorized translation by William Goodwin. Second edition revised. Pp. xiii+328. (London : Gerald Duckworth & Co.) Price 8*s*. 6*d*. net.
7. Breeding and Improvement of Farm Animals, by V. A. Rice. Pp. xiv+362. (London : McGraw-Hill Publishing Co.) Price 17*s*. 6*d*. net.
8. Soil Conditions and Plant Growth, by Sir John Russell. Fifth edition. Pp. viii 516 6 plates. (London : Longmans, Green & Co.) Price 18*s*.

The following publications has been issued by the Imperial Department of Agriculture in India since our last issue :—

Report.

1. Review of Agricultural Operations in India, 1925-26. Price, Rs. 2-6 or 4*s*. 3*d*.

List of Agricultural Publications in India from 1st August 1926 to 31st January 1927.

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	The *Agricultural Journal of India*, Vol. XXI, Parts V and VI, and Vol. XXII, Part I. Price Re. 1-8 or 2*s*. per part. Annual Subscription, Rs. 6 or 9*s*. 6*d*.	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert and Secretary, Sugar Bureau) for the year 1925-26. Price Rs. 2-4 or 4*s*.	Issued by the Agricultural Research Institute, Pusa.	Ditto.
3	Agricultural Statistics of India, 1924-25. Vol. I, Price Re. 1-5 or 2*s*. 3*d*.	Issued by the Department of Commercial Intelligence and Statistics, India.	Ditto.
4	Statistical Abstract for British India with Statistics, where available, relating to certain Indian States from 1915-16 to 1924-25. Price Rs. 2 or 3*s*. 9*d*.	Ditto . . .	Ditto.
5	Report on the Administration of the Meteorological Department of the Government of India in 1925-26 and a Note on the Long Established Observatories of Madras and Bombay.	The Director General of Observatories.	Government of India Press, Simla.
6	The Coconut. Madras Department of Agriculture Leaflet 44 (English, Kanarese and Malayalam).	M. Govinda Kidavu, Deputy Director of Agriculture, Madras.	Government Press, Madras.
7	Cambodia Cotton. Madras Department of Agriculture Leaflet 45 (English, Tamil, Telegu and Kanarese).	Issued by the Department of Agriculture, Madras.	Ditto.
8	Villagers' Calendar, 1927 . .	Ditto . . .	Ditto.

List of Agricultural Publications.

No.	Title	Author	Where published
	General Agriculture—contd.		
9	Manuring of Sugarcane. Bombay Department of Agriculture Leaflet 2 of 1926.	Issued by the Department of Agriculture, Bombay.	Yeravada Prison Press, Poona.
10	Some of the Promising Exotic Sugarcane Varieties of the Manjri Farm. Bombay Department of Agriculture Bulletin 125. Price As. 13.	Rao Bahadur P. C. Patil, M.Sc., L.Ag., Principal, Agricultural College, Poona; and V. G. Patwardhan, B. Ag.	Ditto.
11	The Treatment of Patches of inferior Tobacco in North Gujarat. Bombay Department of Agriculture Bulletin 129. Price As. 1½.	Dr. Harold H. Mann, Director of Agriculture, Bombay; M. L. Patel, M. Ag., and V. M. Majumdar, B. Ag.	Ditto.
12	Some useful Forest Trees and Shrubs of the Coastal Tract and their Fodder Value. Bombay Department of Agriculture Bulletin 130. Price As. 8.	Mr. M. S. Tuggerse . .	Government Central Press, Bombay.
13	The Improvement of Tobacco in Northern Gujarat. Bombay Department of Agriculture Bulletin 132. Price As. 4.	Dr. Harold H Mann, Director of Agriculture, Bombay; M. L. Patel, M.Ag., and V. M. Majumdar, B. Ag.	Yeravada Prison Press Poona.
14	Annual Season and Crop Report of the Bombay Presidency for 1925-26. Price Re. 1-10.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
15	Artificial Farmyard Manure (English). Bengal Department of Agriculture Leaflet 1 (English and Bengali).	R. S. Finlow, B Sc., F.I.C., Director of Agriculture, Bengal.	Sreenath Press, Dacca.
16	Paddy Seed Farm (English and Bengali).	Ditto . . .	Ditto.
17	Report on the working of the Department of Agriculture, Central Provinces, 1925-26. Price Re. 1.	R. G. Allan, M.A., Offg. Director of Agriculture, Central Provinces.	Government Press, Nagpur.
18	Comments on the return of expenditure of the Provincial and District Gardens in the Central Provinces and Berar for the year ending the 31st March, 1926.	Ditto . . .	Ditto.
19	Annual Report of the Department of Agriculture, Bihar and Orissa for 1925-26.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gulzarbagh.

LIST OF AGRICULTURAL PUBLICATIONS.

No.	Title	Author	Where published
	General Agriculture—contd.		
20	Agricultural Statistics of the Department of Agriculture, Bihar and Orissa, 1925-26.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gulzarbagh.
21	Report of the Department of Agriculture, Assam, for the year ending on 31st March, 1926.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
22	Practical Suggestions to Orange Growers. Assam Department of Agriculture Leaflet 1 (Bengali, Assamese, Khasi).	Ditto . . .	Ditto.
23	Leaf curl in Litchi. Assam Department of Agriculture Leaflet 2.	Ditto . . .	Ditto.
24	Vegetable Seeds. Assam Department of Agriculture Leaflet 3	Ditto . . .	Ditto.
25	Humus in Assam Soil; its deplotion and means of Recuperation. Assam Department of Agriculture Bulletin 1.	Ditto . . .	Ditto.
26	Annual Report on the Administration of the Department of Agriculture, United Provinces, for the year ending 30th June, 1926.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
27	Report on the Agricultural Stations of Central Circle, Cawnpore, United Provinces, for the year ending 30th June, 1926.	Ditto . . .	Ditto.
28	Report on the Agricultural Stations of Western Circle, United Provinces, for the year ending 30th June, 1926.	Ditto . . .	Ditto.
29	Combined Report on the Experimental Stations in the Eastern Circle, United Provinces, in the year ending 31st May, 1926.	Ditto . . .	Ditto.
30	Report on the Agricultural Stations of the North-Eastern Circle, United Provinces, for the year ending 30th June, 1926.	Ditto . .	Ditto.

List of Agricultural Publications.

No.	Title	Author	Where published
	General Agriculture—contd.		
31	Report on the Agricultural Stations in the Rohilkhand Circle, United Provinces, for the year ending 30th June, 1926.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
32	Report on the Agricultural Stations in the Bundelkhand Circle, United Provinces, for the year ending 30th June, 1926.	Ditto . . .	Ditto.
33	Report on the Working and Administration of the United Provinces Government Gardens for the year ending 30th June, 1926.	Ditto . . .	Ditto.
34	Season and Crop Report of the Punjab for the year 1925-26.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
35	Tables of Agricultural Statistics of the Punjab for the year 1925-26.	Ditto	Ditto.
36	Part II of the Report on the Operations of the Department of Agriculture, Punjab, for the year ending 30th June, 1925.	Ditto . . .	Ditto.
37	Seasonal Notes for October, 1926.	Ditto . . .	Ditto.
38	Notes on the harvest of cane and manufacture of *Gur*.	Malik Sultan Ali, Deputy Director of Agriculture, Gurdaspur.	Ditto.
39	Report on the Economic Position of the Sugarcane Crop in the Punjab.	Ch. Mohd. Abdullah, Deputy Director of Agriculture, Multan.	Ditto.
40	Report on the Operations of the Department of Agriculture, Burma, for the year ended 30th June, 1926.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
41	Report on the Mandalay Agricultural Station, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto.
42	Report on the Mahlaing Agricultural Station, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto.
43	Report on the Padu Agricultural Station, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto.

List of Agricultural Publications.

No.	Title	Author	Where published
	General Agriculture—contd.		
44	Report on the Hmawbi Agricultural Station, Burma, for the year ended 30th June, 1926.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
45	Report on the Tatkon Agricultural Station, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto.
46	Report of the Agricultural Engineer, Burma, for the year ended 30th June, 1926.	Ditto . .	Ditto.
47	Report on the Pwinbyu Seed Farm, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto
48	Report on Sericulture, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto.
49	Combined Report of Akyab Agricultural Station and Kyaukpyu Coconut Farm, Burma, for the year ended 30th June, 1926.	Ditto . . .	Ditto.
50	Economic Survey of the Sugarcane Industry in the East Central, Tenasserim and Northern Agricultural Circles, Burma, for the year ended 30th June, 1926.	Issued by the Department of Agriculture, Burma.	Ditto.
51	Report on the Flora of the Agricultural College Station, Mandalay.	A. M. Sawyer, Assistant Director.	Ditto.
52	Agricultural Statistics of Burma for the year 1925-26. Price Rs. 2 or 3*s*.	Commissioner of Settlement and Land Records, Burma.	Ditto.
53	*The Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual Subscription, Rs. ?.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
54	*The Journal of the Madras Agricultural Student's Union* (Monthly). Annual Subscription, Rs. 4; Single copy As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
55	*The Planters Chronicle* (Weekly) .	United Planters' Association of South India.	Diocesan Press, P. B. 455, Madras.

LIST OF AGRICULTURAL PUBLICATIONS.

No.	Title	Author	Where published
	General Agriculture—concld.		
56	*The Nagpur Agricultural College Magazine* (Quarterly). Annual Subscription, Rs. 3.	R. A. Ramayya and R. B. Ekbote, Editors.	Udyama Desha Sevak Press, Nagpur.
57	*Poona Agricultural College Magazine* (Quarterly). Annual Subscription, Rs. 2-8; single copy, As. 10.	College Magazine Committee, Poona.	Agricultural College, Poona.
58	*The Old Boys' Magazine, Agricultural College, Cawnpore.* (Quarterly). Price As. 8 per copy; Annual Subscription Rs. 2.	M. L. Saksena, L.Ag., Editor.	Cawnpore Printing Press.
59	*The Allahabad Farmer.* (Quarterly). Single copy, As. 8; per year Rs. 2.	W. B. Hayes, E. W. Jeremy, J. N. Shivpuri.	The Mission Press, Allahabad.
60	*The Bengal Agricultural Journal* (Quarterly) (In English and Bengali). Annual Subscription, Re. 1-4, Single copy As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
61	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
62	*Indian Scientific Agriculturist* (Monthly). Annual Subscription Rs. 4.	H. C. Sturgess, Editor, J. W. Mckay, A. R. C. Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Co., 52-53, Bowbazar Street, Calcutta.
63	*Rural India.* (Monthly.) Single copy, As. 6; Annual Subscription Rs. 3.	A. Swaminatha Ayyar .	President, Forest Panchayet Banking Union, Madras.
	AGRICULTURAL CHEMISTRY		
64	A Study of Absorption of Moisture by Soils. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VIII, No. 12. Price As. 6 or 9*d*.	J. Sen, M.A., Ph.D., Biochemist, Forest Research Institute, Dehra Dun, and Bhailal M. Amin, B.A.	Government of India Central Publication Branch, Calcutta.
65	The Selection of Burma Beans (*Phaseolus lunatus*) for Low Prussic Acid Content. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 1. Price As. 10 or 1*s*.	J. Charlton, M.Sc., F.I.C., Agricultural Chemist, Burma.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS.

No.	Title	Author	Where published
	Agricultural Chemistry—concld.		
66	Bangalore Maintenance Experiments, First Series. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 2. Price As. 11 or 1s. 2*d*.	F. J. Warth, M.Sc., Physiological Chemist, Imperial Institute of Animal Husbandry and Dairying, Bangalore.	Government of India Central Publication Branch, Calcutta.
67	Report of the Agricultural Chemist, Burma, for the year ended 30th June, 1926.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
	BOTANY		
68	Sugarcane Breeding—Indications of Inheritance. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIV, No. 3. Price As. 8 or 10*d*.	Rao Saheb T. S. Venkatraman, B.A., Government Sugarcane Expert, Coimbatore.	Government of India Central Publication Branch, Calcutta.
69	Work of the Ganeshkhind Botanical Gardens and Modibag Garden for the years 1921-25. Department of Agriculture, Bombay Bulletin 133. Price As. 2.	Issued by the Department of Agriculture, Bombay.	Yeravada Prison Press, Poona.
70	Report of the Economic Botanist, Burma, for the year ended 30th June, 1926.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
	MYCOLOGY		
71	The Mosaic Disease of Sugarcane. Madras Department of Agriculture Leaflet 42 (English, Tamil, Telugu, Malayalam and Kanarese).	S. Sundararaman, M.A., Government Mycologist, Coimbatore.	Government Press, Madras.
72	The Diseases of Para Rubber in Burma.	D. Rhind, B.Sc., Mycologist to Government, Burma.	Government Printing, Burma, Rangoon.
73	Report of the Mycologist, Burma, for the year ended 30th June, 1926.	Ditto.	Ditto.
74	Treatment of Gum Disease of Mosambi Plants. Bombay Department of Agriculture Leaflet 8 of 1926.	Issued by the Department of Agriculture, Bombay.	Yeravada Prison Press, Poona.

LIST OF AGRICULTURAL PUBLICATIONS.

No.	Title	Author	Where published
	ENTOMOLOGY		
75	Studies on Indian Thysanoptera. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. IX, No. 6. Price Re. 1-8 or 2*s*. 6*d*.	Dr. H. H. Karny . .	Government of India Central Publication Branch, Calcutta.
76	New Species of Indian Gall Midges (*Itonididæ*).	E. P. Felt . . .	Ditto.
	New Indian Geometridæ . .	Lewis B. Prout, F.E.S. .	Ditto.
	Description of *Laspeyresia stirpicola*, n. sp. (Lepidoptera) with	E. Meyrick, F.R.S. .	Ditto.
	A short note on the Life history and status. Memoirs of the Department of Agriculture in India, Entomological series, Vol. IX, Nos. 7 to 9. Price As. 5 or 6*d*.	Rao Bahadur C. S. Misra, B.A.	Ditto.
77	List of Publications on Indian Entomology. Pusa Agricultural Research Institute Bulletin No. 165.	Compiled by the Imperial Entomologist and the Officiating Imperial Entomologist, Pusa.	Ditto.
78	The Catalogue of Indian Insects. Part 11 Brenthidæ. Price Re. 1-2 or 2*s*.	Richard Kleine . .	Ditto.
79	Jute Semi-Looper. Assam Department of Agriculture Leaflet 4 (English, Assamese and Bengali).	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
	VETERINARY		
80	Experiments on the treatment of Hookworm Infection in Dogs. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. III, No. 7. Price As. 11 or 1*s*. 3*d*.	Amarnath Gulati, M.Sc., Imperial Institute of Veterinary Research, Muktesar.	Government of India Central Publication Branch, Calcutta.
81	On the Occurrence of a Lung Fluke *Paragonimus edwardsi*, n. sp. in a Palm Civet (*Paradoxurus grayi*) in Kumaun Hills.	Ditto . . .	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS.

No.	Title	Author	Where published
	Veterinary—contd.		
	On the Occurrence of *Isospora* and *Balantidium* in Cattle. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. III, Nos. 8 and 9.	H. Cooper, M.R.C.V.S., and Amarnath Gulati, M.Sc., Imperial Institute of Veterinary Research, Muktesar.	Government of India Central Publication Branch, Calcutta.
82	Annual Administration Report of the Civil Veterinary Department, Madras, for 1925-26. Price As. 12.	Veterinary Adviser to the Government of Madras.	Government Press, Madras.
83	Annual Administration Report of the Bombay Veterinary College, Bombay City and Harbour Veterinary Department and Civil Veterinary Department in the Bombay Presidency (including Sind) for 1925-26. Price Re. 0-14-6 or 1*s*. 6*d*.	Issued by the Civil Veterinary Department, Bombay.	Government Central Press, Bombay.
84	Annual Report of the Civil Veterinary Department, Bihar and Orissa, for 1925-26. Price Re. 1-6.	Director, Civil Veterinary Department, Bihar and Orissa.	Government Printing, Bihar and Orissa.
85	Annual Report of the Civil Veterinary Department, United Provinces, for the year ending 31st March, 1926. Price Re. 1-14.	Issued by the Civil Veterinary Department, United Provinces.	Government Press, United Provinces, Allahabad.
86	Report of the Civil Veterinary Department of Agriculture of the Central Provinces and Berar during the year 1925-26. Price Re. 1-10.	Issued by the Civil Veterinary Department, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
87	Report of the Civil Veterinary Department, Assam, for 1925-26. Price As. 8 or 9*d*.	Issued by the Civil Veterinary Department, Assam.	Assam Secretariat Printing Office, Shillong.
88	Report of the Civil Veterinary Department, Burma (including the Insein Veterinary School) for the year ended the 31st March, 1926. Price, Re. 1-4 or 1*s*. 11*d*.	Issued by the Civil Veterinary Department, Burma.	Government Printing, Burma, Rangoon.
89	Annual Administration Report of the Civil Veterinary Department, North-West Frontier Province, for 1925-26. Price Re. 1-3.	Issued by the Civil Veterinary Department, North-West Frontier Province.	North-West Frontier Province Government Press, Peshawar.

List of Agricultural Publications.

No.	Title	Author	Where published
	Veterinary—concld.		
90	List of Horses and Cattle Fairs in the Punjab.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
91	Surra Transmission Experiments .	S. Kahan Singh, Officer in charge of the Office of the Camel Specialist, Sohawa (Jhelum).	Ditto.
92	*The Indian Veterinary Journal* (Quarterly). Annual Subscription, Rs. 4 for members of All-India Veterinary Association and Students ; Rs. 8 for others.	P. Srinivasa Rao, G.M.V.C., Editor.	Methodist Publishing House, Madras.

EDITORIAL

I WOULD draw the attention of the readers of the " Agricultural Journal of India " to the " Journal of the Central Bureau for Animal Husbandry and Dairying in India " the first number of which appeared in May of this year. This new Quarterly deals with cattle-breeding, dairying, the cultivation and storage of fodder crops, animal nutrition, and other aspects of animal husbandry.

Intending subscribers should write to the Manager, Government of India Central Publication Branch, 3, Government Place, West, Calcutta, from whom copies can be had. The Journal is edited by the Agricultural Adviser to the Government of India, Pusa, Bihar.

For the first number of this new Journal, His Excellency the Viceroy has very graciously written a foreword in which he wishes this new venture God-speed in the following words :—

" Since the Great War agriculture in England has passed through a period of acute depression. Fluctuating prices and unstable markets have hit farmers badly, and they have been forced to realize that agriculture cannot pay unless it is worked on scientific lines. They are now anxious to take advantage of all that scientific research and experiment can give them, and they are also paying greater attention to the fundamental principles of cattle-breeding, cattle-feeding, cattle diseases and dairying, and to the general economics of animal husbandry.

" Here in India the same problems confront us as in England, and we must move with the times.

" Thanks to the efforts of the Imperial and Provincial Departments of Agriculture much is already being done. Cattle-breeding farms have been established, pure-bred herds evolved by selection, and improved bulls supplied for stud purposes to cattle-owners. Successful experiments have been made to increase the milking capacity of cows, and continuous efforts are being made to produce sound dual-purpose breeds. Courses of instruction in dairying have been instituted, and investigations into the principles underlying stock-feeding have been carried out.

" In these ways Government is doing a good deal to improve animal husbandry and dairying, but this is not enough. It is on the big landholders that the country must depend if real progress is to be made.

" For the past two centuries England's gentlemen farmers have taken the lead in stock-breeding. They felt that this leadership was a duty they owed both to the farming community and to the State, and as a result of their efforts stock-

breeding has been the mainstay of British agriculture, and England has become the Stud Farm of the world.

"Let India's landed aristocracy follow their example.

"Scientific cattle-breeding does not ordinarily pay to-day because it costs more to breed and rear good animals than they are worth when reared, and ready for disposal. But this is because cattle-owners are not as yet sufficiently enlightened to pay for pedigree. It is the function of those who can afford it to realize their social obligations and develop cattle improvement on scientific lines, even if it does not bring them immediate financial reward. The time will undoubtedly come when sufficient farmers will realize its value and be prepared to pay for it.

"At present the tendency of the educated classes is to immerse themselves in politics or the law. These two spheres of action are important and necessary for the constitutional administration of the country, but they are not the vital necessities on which the people of India depend for their very existence from day to day. What is the good of concentrating on strong reins to drive a horse or on rubber-tyred wheels to make the carriage comfortable if the horse is so weak that he cannot pull the carriage, or the carriage so frail that it falls to pieces directly anybody sits in it?

"Education therefore should be directed into practical channels, and it should be the first aim of all of us to do everything that we can to foster and improve that basic industry of agriculture on which India more perhaps than any other country is dependent.

"One of the principal objects of this Journal will be to stimulate the interest of Indian landowners in animal husbandry, and to gain their support in building up Indian pedigree herds. I commend this object to everyone who is interested in the material and moral welfare of the people of India, and as head of the administration of this great country, and as one who has always taken a keen and personal interest in all that pertains to agriculture, I wish the Journal all success."

DR. E. J. BUTLER, C.I.E., F.R.S.

ORIGINAL ARTICLES

EDWIN JOHN BUTLER, C.I.E., D.Sc., M.B., F.L.S., F.R.S.

Dr. Butler has retired from the post of Imperial Mycologist in the Indian Agricultural Service after a service of twenty-five years, nineteen of which were spent in India. He was born in 1874 and educated at Cork from which university he graduated M.B. with honours. He spent a further period of two years in England, France and Germany in post-graduate study on plant-pathology. In 1901 he was appointed Cryptogamic Botanist to the Government of India and joined duty as a colleague of Sir David Prain and Col. Gage at the Royal Botanic Garden, Sibpur, where so many eminent botanists have begun their career. A year afterwards he was transferred to the Imperial Department of Agriculture and went to Dehra Dun for three years. Towards the end of 1905 he was transferred to Pusa with the designation of Imperial Mycologist to join the staff of agricultural workers that Mr. Mollison, the Inspector General of Agriculture, was organizing to lead the way in the investigation of agricultural science in India. Here he remained till 1920 when he became the first Director of the Imperial Bureau of Mycology, London.

All the difficulties attending the opening of a new Section he overcame and soon had a staff working on problems in plant diseases on important crops in widely separated parts of India. His work on plant-pathology in India is well known both in this country and abroad. More than fifty publications stand to his credit in the "Agricultural Journal of India," the Memoirs and Bulletins of the Imperial Department of Agriculture in India, and also several foreign journals dealing with mycology. His book on Fungi and Disease in Plants brings together in convenient form his extensive knowledge about Indian crop-diseases and is most useful to mycologists and agriculturists both in India and in other countries, and they have appreciated it so well that the first edition is already out of print.

The development of the herbarium at Pusa was one of Dr. Butler's great aims. Now it contains many named specimens of fungi on cultivated and wild plants from India and elsewhere available for mycological workers in India and a mass of partially named material which forms a connecting link between Dr. Butler and his old laboratory, for he is still most interested as Director of the Imperial Bureau of Mycology in helping to have the various specimens named.

Dr. Butler took a keen interest in his students, encouraged and developed research ability wherever it was shown. In most provinces in India are one or two men who drew inspiration from his teaching. To the members of his staff he was kind and sympathetic and helped them over many a rough place. They have a genuine

regard for him, and still speak of him with marked respect. In addition to his duties as Imperial Mycologist, Dr. Butler was for some time Joint Director of the Agricultural Research Institute at Pusa where he performed the duties of unifying and guiding the activities of the various Sections with tact and success, and for two months prior to his final departure from India he officiated as Agricultural Adviser to the Government of India. In recognition of his services he was decorated in 1912 with the Companionship of the Order of the Indian Empire.

In private life Dr. Butler was a most genial companion. Joining the department in its earliest days, touring all over India, and being present at all the meetings of the Board of Agriculture, he had opportunities of knowing intimately most of the members of the Agricultural Service. His stories of their doings and sayings, pointed with wit never with venom, told, as they were, with a twinkle in his eye and his ready laugh, were a never ending source of amusement. In spite of his inability to take part in the rough and tumble of games he was a keen sportsman and took an enthusiastic interest in the games and athletic activities of the staff of the Institute.

He has made his mark as a scientist of distinction in England and is the first member of the Indian Agricultural Service to become a Fellow of the Royal Society of England. Eminent and inspiring as a mycologist, genial and steadfast as a friend, Dr. Butler lives in the memory of many friends left behind in India who wish him a long life of health and prosperity in his new career.

W. McR.

THE *CATTEDRE AMBULANTI* OF ITALY AND THE TRAINING OF THE PEASANT.

BY

M. L. DARLING, B.A., I.C.S.,

Commissioner of Income-Tax, Punjab and N.-W. F. Province.

It was, I think, Pope Julius II who remarked that men are more influenced by what they see than by what they hear. The cinema suggests that this is true of the mass of mankind. It is certainly true of the uneducated mind, of which a good example is the *tongawala* who, when he hears the horn of a car coming up behind, invariably looks round before getting out of the way to see if the car is really there. To the same category belongs the peasant. In him lack of education is intensified by a singularly concrete outlook upon life which makes it difficult for him to understand a new idea or even a fact, unless it is put before him in some visible tangible form. And he has suffered so much in the past from men quicker-witted than himself that he is deeply mistrustful of all who come before him with new nostrums. To persuade him, therefore, to change a traditional method, it is necessary to demonstrate not only that the new method is possible but also that it pays. Even in the United States, where nearly all can read and write, it is said that "though hundreds of millions of pages of literature have been distributed (amongst the farmers), only a small percentage has actually been read, and only a small percentage of that read has been put into practice."[1] Two thousand "country-agents" are now maintained in the States to act as a link between the experimental farm and the individual farmer, and we read that "the success of the continental and still more of the United States educational work is largely due to the provision which has been made for bringing down to the farm the information gained by investigation and research."[2] All authorities are, in fact, agreed that demonstration is the most effective way of teaching the peasant; and, since it is becoming increasingly clear that this applies to India, some account of the Italian organization known as the *Cattedre Ambulanti*, of which I had the good fortune to see something in the winter of 1925, may be of interest, especially as the problems of the Italian countryside have much in common with those of the Indian.

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[1] *C. M. D. 2145*, Memo. XI.
[2] *Ibid*, paras. 165, 170(4).

ORGANIZATION.

Cattedra Ambulante means literally an itinerating chair, the last word being used in the academic sense of a chair of history or philosophy. The first Chair was created in 1896, and thirty years later, at the beginning of 1926, there were over 100. It was then proposed to double the number in furtherance of Mussolini's campaign to improve the wheat supply of the country, commonly called "*la battaglia di grano.*" Each of Italy's 71 districts (Provincia) has at least one Chair and many have branches in the larger country towns. The district of Rome, for instance, had ten in 1925, and in the whole country there were 304. Every office is in charge of a director, and, if a headquarter office, there are two or three assistants as well. The combined staff totals nearly 500 men, most of whom have taken the highest possible diploma in agriculture.*

The first point to emphasize is that a *Cattedra Ambulante* is not an official body. The earliest were the product of spontaneous local effort unassisted by Government. A District Board combined with the local People's Bank and Landowners' Association, and between them the £250 or £300 a year required to start a Chair were found. Before the war, few had a budget of more than £500. It was not till the movement was launched that Government gave any help, nor till after the war that it bore the major part of the cost. In 1919, a substantial grant was made and divided equally between all the Chairs. But this equality of treatment proved most unequal in operation, as districts varied in size and Chairs in activity. Since 1923, the grants made by Government and local bodies have been proportioned to needs on the following basis :—One lira for every 25 acres of cultivation within the Chair's area ; half a lira for every 25 acres of wood, meadow and pasture ; another half lira for every rural inhabitant ; 100 lira for every commune or village area ; sixteen for every mile of communications and ten for every sub-division of a commune (*frazione*). The total grant was £140,000, of which three-fifths are contributed by the State and two-fifths by the District Boards.† Both parties are represented on the managing committee of each Chair, Government by one member and the District Board by from three to five. To strengthen their organization and coordinate their work, the Chairs have federated themselves into a 'Union' with a Director General as the chief executive authority. To meet its expenses, the Union is allotted two per cent. of the amount contributed by Government and one per cent. of the amount contributed by the District Boards : the former is paid direct and the latter by each Chair from its own grant.

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* Chairs and their branches now number 560 and enjoy an annual grant of 16 million lira from Government (see the 1927 report on the Wheat Campaign by the Italian Ministry of National Economy).

† In this article all post-war payments have been converted from lira into sterling at 120 lira to the pound, which was the approximate rate of exchange in the winter of 1925.

Functions.

The sole object of a *Cattedra Ambulante* is the encouragement of better farming. This it does in a number of different ways; most of them based upon some form of demonstration. The simplest, and perhaps the most effective, is the demonstration plot. As in the Punjab, where in 1917 the writer was the first to introduce the method, an intelligent owner is persuaded to cultivate from two to three acres of his land on approved methods in order to demonstrate to the neighbourhood their superiority over traditional practice. In 1925, there were as many as 50 in the single district of Rome, of which twenty were devoted to the culture of fruit, and in 1926-27, as a result of the Wheat Campaign, the total number in the whole country was 8,998. In addition to demonstration plots, large gatherings of cultivators are organized to discuss the problems of the district, and conferences of a dozen or twenty to consider how these problems can be solved. Farmers are encouraged to consult the staff about their individual problems, and, if advice is needed about seed, cattle or crop, it is promptly given. If necessary, the farm itself is visited, and this is not difficult as every Chair has at least one motor car. A farmer comes into the office in the morning to say that he is in difficulties with a horse or a cow and the same afternoon, with the help of the car, horse or cow can be examined and treatment prescribed. Only less important than the car are the magic lantern and the cinema. These are both freely used in the educational courses described below.

The Cattedra Ambulante of Siena.

Three Chairs were visited, and the best of the three, that at Siena, will be described at length, as it shows how a good Chair is run. The Chair at Rome will also be referred to, but the third shall be nameless, as it had run to seed under the influence of a director without either capacity or enthusiasm. The success of a Chair depends almost entirely upon the personal factor, as is always the case when initiative, enterprise and tact are required rather than a strict adherence to rule and routine. This is a point to be remembered if the organization is copied in India.

The town of Siena, famous for its Cathedral, its saint and its horse races, is the capital of a hilly district situated in the heart of Central Italy. The cultivator is prosperous as holdings are large, averaging from 20 to 25 acres where cultivation is based upon the vine and the olive, and fifty acres where it is based upon cereals. To the Punjab peasant with his 5 or 10 acres these will seem generous figures, but they are not quite as generous as they seem, for the soil produces only one crop a year and in some parts is so hard that virgin land has to be broken up by explosives. Even where the vine and the olive are cultivated, from fifteen to twenty acres are required to maintain the small proprietor and his family in comfort, and from 35 to 40 where cereals prevail. In the more mountainous parts of the district many have less than 5 acres, and are obliged to do other work to make both ends meet.

The famous *metayer* system, under which both expenditure and income are shared by landlord and tenant, is common, but since the war, which has enriched the peasant, many tenants have become proprietors. The peasants are now so well off that the *Monte dei Paschi*, a well-known local bank, which for the last 300 years has been run for the common good of the district, is now mainly supported by their deposits. Fortunately, prosperity has not had the corrupting influence that it has had in some parts of the Punjab. The peasant spends his money well, and it is only when he lives in the neighbourhood of a town that he is a little extravagant. The proportion of illiterate, 30 to 35 per cent., is greater than one would expect in the northern half of the peninsula. But literacy, beyond making a farmer quicker to pick up a new method, is said to have very little effect upon cultivation.

Founded in 1901, the Siena Chair is staffed at headquarters by a director, an assistant and a cattle expert. There are two out-stations each in charge of a director, and for propaganda on special subjects specialists are temporarily engaged. The annual budget amounts to £2,200, contributed in varying proportions by Government, the local District Board, the 36 communes of the district and a number of co-operative societies. There are in addition special grants, which in 1925 were as follows :—£525 for technical education, mostly for boys : £350 for the rearing of good live-stock—high class pigs had been obtained from Reggio Emilia and a good breed of sheep from the Roman Campagna ; and £2,200 for the *battaglia di grano* to be spent upon demonstration plots, prizes, concessions, and the maintenance of an agent in each commune, etc. £700 of this came from Government, and the rest from the District Board, the local landowners' association, the district co-operative Supply Society and the *Monte dei Paschi*. Total resources, therefore, in 1925 amounted to over £5,000, a considerable sum when it is remembered that the population of the district is less than 400,000. But the Chair was not always so prosperous. It began operations with an income of only £300 subscribed by Government, the District Board, the *Monte dei Paschi*, the municipality of Siena and the local agricultural association. The director was paid £160 a year and his assistant £80. This did not leave much for the work of the Chair, and there was much to be done, for many obstacles had to be overcome. Landowners were apathetic and generally absentee ; their factors were hostile, and the peasants sunk in ignorance. The first step, as my informant expressed it, was to awaken " the rural conscience." This was done by talking to the peasant on his farm, explaining things to small groups of those who were anxious to improve their position, and demonstrating new methods. A more general appeal was made by local conferences, of which as many as fifty were sometimes held in a year, and by offering prizes of from five to twenty pounds to be competed for by the more enterprizing farmers. That these efforts have succeeded may be shown by a single example. In 1902, the year after the Chair was created, only 650 tons of chemical fertilizers were sold by the local Supply Society : by 1924 the amount had risen to nearly 20,000, and a year later, thanks to the *battaglia di grano*, to close on 30,000.

LA BATTAGLIA DI GRANO.

A word may be said in passing about this "battle of the grain," as Mussolini's intensive campaign for increasing the wheat supply of the country is characteristically called. The campaign has been launched, as large quantities of wheat have to be imported every year and it is believed that, if Italy could manage to grow all the wheat she requires, imports and exports would balance and the lira, long in danger, would be saved. To India the experiment is of some interest, as it will show whether in a country not entirely dissimilar it is possible by organized effort substantially to increase the yield of a staple crop in a comparatively short space of time.[1] In Siena, the peasant is being urged to put not more, but less land under wheat. The explanation of this paradox is worth noting. Hitherto the customary rotation has been beet-root or tobacco, wheat and clover sown together, followed by clover alone and finally wheat. The ideal holding was one divided into four parts, each representing a different stage in the fourfold rotation. Now it is proposed to divide it into five parts, cultivated thus :—

Beet-root or tobacco	one-fifth
Wheat and lucerne	one-fifth
Lucerne	two-fifths
Wheat	one-fifth

It is believed that with this rotation the smaller area under wheat will produce a larger crop. More fodder will also be produced, and with more fodder more cattle can be kept. This again means more manure and better crops all round. The effect is, therefore, cumulative and touches everything in turn. The moral is that, for real improvement, the farm must be considered as a whole. This is, perhaps, a commonplace, but it is apt to be forgotten when, as in this country, agricultural progress has to be approached through a number of different departments each wedded to its own particular activity. We shall, therefore, be none the worse for reminding ourselves occasionally that a farm is a living organism, distinct no doubt in its parts but bound together by a common life and existing for a single purpose, the welfare of the farmer.

THE TRAINING OF THE PEASANT.

That this organism may thrive, it is necessary that the farmer should be trained. This necessity has become more obvious of late, for since the war the peasant has been getting more and more control over the land. The labourer now becomes a tenant at will, the tenant at will a leaseholder or a *metayer* tenant, and all aspire "with incredible fervour"[2] to become proprietors. At each stage in the upward

[1] In 1926, though the year was unfavourable, the average yield of wheat for the whole country was about 18¼ bushels per acre (12·2 quintals per hectare) as against an average of 16½ (11 quintals per hectare) for the years 1920-25 (see report already quoted).

[2] Vigorelli, *Un Saggio di inchiesta sulla Piccola Proprietà in Italia*, 1921, p. 10.

process more knowledge is required, and Serpieri, the leading rural economist in Italy, considers that the ultimate social effect of the process, whether for good or ill, will largely depend upon whether this knowledge is gained.[1] It is to assist the peasant to gain this knowledge that educational courses have been instituted. These are now one of the chief activities of a Chair and include short courses for the farmer and longer ones for his boys. Both are entirely vocational and are based on the principle that, as the peasant will not go to the school, the school must go to the peasant. In both cases, therefore, an itinerating master is employed, and the closest possible contact is maintained with the farm.

Let us take the adult courses first. At Siena, twelve are held every year by the director and his assistants, and as there are 36 communes in the district and a regular rotation is followed, each commune gets a course once every three years. Attendance averages about 40 and includes men of all ages with a predominance of those between 20 and 30. A dozen lectures are given of 30 to 35 minutes each—it is found difficult to hold the attention for longer—and each lecture is followed by an hour's discussion. A number of different subjects are dealt with in a single course, but at Rome, which would seem greater wisdom, one course one subject is the rule, as it is believed that the peasant mind can grasp only one thing at a time. Thus, a whole course is devoted to potato-growing, another to grafting and a third to machinery and implements. The theory or structure of the subject is taught in the school-room, and its practice, so far as possible, in the field. Both magic lantern and cinema are freely used. The latter is found most effective (in France as well as in Italy) and a portable machine can now be had for £30. No charge is made for the teaching and all travelling expenses are paid. Those who show most intelligence and capacity are taken on a tour of inspection round the district, while others are given prizes of implements or books. Both at Rome and at Siena the results are said to be excellent, for those who are taught not only benefit themselves, but spread the teaching to others. At Rome I was informed that there was not much to choose between the literate and the illiterate—an interesting point, as a report of the Italian Budget Committee of 1924 [2] states that vo ational training is of little use if the mind has not been prepared for it by some measure of general instruction.

THE TRAINING OF THE PEASANT'S BOY.

The courses for boys follow somewhat different lines. They were only started in 1924 and are the result of an official Commission which in 1917-21 enquired into the condition of the peasant proprietor in different parts of Italy. The Commission's report states that there are two ways of giving the young an agricultural education. One is to graft it onto the primary school and give it through the primary

[1] For Professor Serpieri's views on agricultural education, see his book, *La Politica Agraria in Italia,* 1925, pp. 145-161.

[2] Dated 20th December 1924.

school teacher, and the other to give it through a special staff to boys who have passed through the primary school. The former is much less costly, but the Commission is against it, as most of the teachers are of urban origin and incapable of teaching agriculture, and their liability to constant transfer makes continuity of teaching difficult.[1] They, therefore, recommend the latter, and it is the course advocated both by Serpieri and by Laribé, the leading rural economist in France.[2] Both these authorities are agreed that the primary school is not the place for vocational training, and that all that can be done there is to give the school a rural tone and keep the youthful peasant mind fixed upon the land and turned away from the town. This is in itself a sufficiently difficult task, and the complaint is made by the Commission that the present educational course kills the peasant in the pupil.[3] The urban school, says Serpieri, has been fostered at the expense of the rural. The former is fairly efficient, but the latter has been neglected and leaves everything to be desired.[4] The differences between the rural and the urban mind, which still exist "in the strongest measure,"[5] are a further complication, and even the secondary agricultural schools do little more than train a very limited number of boys for technical posts and the charge of the larger farms. In all of which we are vividly reminded of conditions in this country.

The object of the courses started in 1924 is to catch the intelligent boy when he leaves the primary school and teach him the elements of agricultural science, while his mind is still plastic and before he has had time to forget how to read and write. A secondary object is to correct the urban bias of an education based primarily upon the pen. The courses are confined to boys of 14 to 17, who have passed through the top form of a primary school and have, therefore, really absorbed the primary course. Subject to this, anyone is admitted who is connected with the land, but the son of a proprietor is preferred to the son of a tenant and the son of a tenant to the son of a labourer, as in each case the need for training is greater. About twenty boys are taught at a time and 80 lectures (*lezioni*) are given, spread over a period of three or four months. Each master holds three courses a year in different communes and, that the effect may be lasting, repeats them three years running in each commune. He uses the local primary school, which the educational authorities are obliged by law to place at his disposal. That his appeal may be as much to the eye as the ear, he is given a magic lantern (weight about 16 lb. and cost £6-10-9) and a large assortment of pictures illustrating the animal and vegetable life of the neighbourhood and the different methods of cultivation with their appropriate implements. It costs about £60 to fit out an itinerating school, and, as the master is paid only £90 a year (including his travelling expenses), the cost is not prohibitive. An annual grant of £50,000 is found sufficient for the purpose and in 1925-26 produced 687 courses attended by 16,221 pupils.

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[1] *Per la Piccola Proprietà Rurale e Montana*, 1922, II, 208-9.
[2] Laribé, *Le Paysan Francais après la Guerre*, 1923, p. 265.
[3] *Op. cit.*, II, 194.
[4] *Ibid*, II, 237.
[5] Serpieri, *Op. cit.*, p. 61.

The crux of the scheme, indeed, is not the cost but the master. The ordinary schoolmaster, says Serpieri, is not suitable, for, even if he has the technical knowledge, he rarely has the right spirit. In his hands instruction "inevitably becomes general and abstract....and may even end in his becoming an object of derision to pupils who live amongst practical farmers."[1] A man who understands both boys and land is required, and he must be a countryman and not a townsman, in order that he may be understood by the peasant. The peasant's vocabulary is not more than three or four hundred words, and a man has almost to be a peasant himself to be able to teach within so narrow a range : yet, beyond this range, as an Italian remarked to the writer, the peasant is lost. It was, therefore, no easy matter to find the 100 masters required to launch the experiment. They have been recruited mostly from farm managers, trained agriculturists and primary school teachers : with what success it is difficult to say, but one may guess that a hundred men of the right stamp are not likely to have been found at a single blast of Mussolini's trumpet.

OTHER COUNTRIES.

Of the experiment as a whole it is too soon to judge. I found no one enthusiastic and some critical. The difficulties are evidently greater than were expected. So far as other countries are concerned, experience is not very decided. Laribé favours it for France, where there are winter schools attended by boys two or three years running for seven or eight weeks.[2] But the experiment there has been handicapped by want of funds and has made but little way. In Germany, there are somewhat similar schools but no widespread popular system of agricultural education, and we read in a recent report that "it is rather through the example of the larger farmers and through the work of the co-operative societies that educational influences have reached the small farmers."[3] On the other hand, Wygodzinsky, a German writer of eminence, says that the agricultural school for adults is "perhaps the most important event that has taken place for decades in the intellectual life of the countryside."[4] Courses for adults would appear so far to have been more successful than courses for boys. In Norway, Sweden and Denmark, they have had a remarkable influence, particularly in Denmark where the "passion and enthusiasm" of the teachers can be "more easily imagined than reproduced."[5] Where this spirit can be evoked, success is sure, whether it is the young or the old who are taught. But where it is lacking, other factors must be carefully considered. The most important of these is the relation of vocational to general education. In Denmark, a boy is allowed to return to his farm on leaving the primary school and

[1] *Op. cit.*, p. 158.

[2] Laribé, *Op. cit.*, 1923, pp. 265-9. In 1921-22 there were 27 winter schools with 392 pupils, and 16 itinerating schools.

[3] *C. M. D. 2145*, para. 161.

[4] *Agrarwesen and Agrar politik*, II, 70.

[5] Strickland, *Studies in European Co-operation*, II, 179. *See* also *C. M. D. 2145*, para. 162 and Memo. IV, paras. 66-9.

spend three or four years there before joining the adult school. The advantage of this is that, when he joins the latter, his mind is mature. But what if in the interval he forgets how to read and write? Here we have a difference between northern and southern Europe, and it is a difference with a lesson for India. Broadly speaking, in the north, once literate always literate, but this is not the case in the south any more than it is in India, for in both a large proportion of those who learn to read and write forget it all in a few years. In Europe this is to some extent a matter of religion. In the Protestant north, the mind of the peasant has come under the grand educating influence of the Bible. For generations he has been accustomed to hear it read, and now when he learns to read, he reads it to himself and is able to carry on the education begun at school. But to the Roman Catholic the Bible is a sealed book and reading too often ceases when the school is left.[1] So is it, too, in India. On leaving school, the boy finds little or nothing to read and quickly forgets what he has learnt; if, therefore, as some think, vocational training requires a literary foundation, it must in this country follow closely upon the primary school or the benefit of the latter will be lost. A possible alternative is to improve the primary school so that its effect endures.

THE PUNJAB.

In the Punjab, agriculture is taught as an optional subject in about 100 vernacular middle schools,[2] which have a garden or small farm (generally the former) attached to them for the purpose, and in 1925-26 over 6,000 boys took it as a subject. But so far, no attempt has been made to give any vocational training either to the grown-up peasant or to the boy whose education stops at the primary school. The immediate problem is to combat the almost universal illiteracy of the countryside; hence the 3,200 adults schools with their 100,000 pupils all learning the three R's. And there is another problem even more urgent, namely, how to make rural education really rural. In the last Education Report (1925-26) we are warned that the application of an urban system to the village may impoverish the village instead of enriching it, and we are told, what some of us have long suspected, that the "university and secondary school systems tend to suck from the countryside its best initiative and talent." There is some truth in the remark made to me by an Italian economist that education distracts the peasant from his calling. At all costs, this must be prevented in India where 224 millions are dependent upon agriculture. In the past, too much honour has been laid upon "the person of the scribe" and too little upon the person of the peasant. For this the urban master with his urban tastes and ties is partially responsible. It is, therefore, a step in the right direction that an attempt is now being made to bring the primary school "into the closest relation to the life and experience of the people." Fifteen hundred village libraries have been started and are being stocked with books likely to interest the peasant

[1] *Inchiesta Parlementare*, 1911, 11 (2), p. 18.
[2] In 1925-26 the number was 80, but this year (1927) it is expected to reach 120.

and broaden his mind. More important, a carefully chosen staff is being trained in two schools (Gurgaon and Gakhar) where the atmosphere is entirely rural and attention is concentrated, on the one hand, upon community work or service, and on the other, upon village occupations and crafts. It is hoped that, when these men go out into the village, they will infuse a new spirit into the village school, the spirit of service rather than gain, of keenness for land and craft rather than for desk and pen, and of content with the country rather than of yearning for the town. If they succeed, the school will become the centre of village life instead of being, as at present, a menace to it, and the most difficult problem of all will be solved.

Outside the school, the method of approaching the peasant is much the same in the Punjab as in Italy, though the agency employed is different. There are "hundreds" of demonstration plots which "could be extended to thousands" if the necessary staff were available.[1] Exhibitions are held at all the more important cattle fairs, and the latter are now attended by manufacturers of machinery and implements for the display of their wares. A popular novelty is the institution of ploughing competitions which draw competitors from all parts and excite the liveliest interest. At one almost Olympian gathering, which was open to the whole of the southern Punjab, 130 appeared to compete for the medals, cups, cash prizes and ploughs offered by District Boards and public-spirited gentlemen. Other ventures are the touring cinema car and the demonstration caravan, which itinerates from village to village with bullocks and improved implements and shows how wheat and cotton should be sown. Then there are 100 co-operative Better Farming Societies, still however in their initial stage, the members of which pledge themselves to follow improved methods. But the most original experiment of all is the selection of 56 villages scattered over the province for intensive development. The object is to modernize them completely and show on a considerable scale what can be done by a rational system of agriculture. The detailed reports about them are of exceptional interest, as they show in concrete form what is actually taking root in the village. They speak again and again of the introduction of improved implements, of Raja and Meston ploughs, chaff-cutters, drills, harrows and hoes, and also of new varieties of wheat, cotton and cane. There is an occasional reference to tube wells, demonstration plots and consolidated holdings, but only one to fruit and manure and none at all to vegetables and cattle. Yet, without an abundant supply of manure, agricultural development cannot go very far, and without fruit-growing, market-gardening or cattle-breeding it is doubtful whether the small holder, who is the typical cultivator of the Punjab, will be able permanently to raise his standard of living. The reports suggest that so far progress has been mainly confined to implements and seed and to the study of two or three staple crops, and that the more difficult questions connected with the supply of manure

[1] *Report of the Department of Agriculture*, 1925-26, p. 37.

and the best system of rotation and farming are still untouched. They suggest, too, with their reiteration of a few forms of improvement, that the problems of different tracts have not been sufficiently studied. In reading them no one would guess that, like Italy, the Punjab has a " wide range of climates, crops and systems of farming."[1] The explanation is that there have not been enough experimental farms. With its population of 15 millions supported by agriculture, the Punjab, till recently, had only three farms as against eight in Italy with a corresponding population of 19 millions,[2] and only one of the three was to any extent a *barani*[3] farm, though more than half the cultivated area of the province is *barani* land.[4] With only three farms, it has been impossible to study different types of cultivation. Attention has been too much concentrated upon cotton and wheat, and too little upon what will benefit the cultivator who has to support a family upon only a few acres. We saw that in the single district of Rome there were as many as twenty demonstration plots devoted to the cultivation of fruit. There is nothing corresponding to this in the Punjab, for, unlike Italy, no systematic experiments have been made in fruit culture except with dates, though parts of the province are well suited to the growing of fruit.[5]

An experimental farm is the necessary background of all demonstration work. It is, therefore, satisfactory to know that two more are on the point of beginning operations and that in a year's time they will be followed by a third. Specialists in fruit and fodder have also been engaged, and the work of the Veterinary Department is being greatly extended, so much so that last year (1925-26) over 600 stud bulls were supplied to the province. Government is now thoroughly alive to the importance of development and, as the cultivator on his side is eager to learn, great things are possible, but it must be some years before the results of the research now being initiated are available. Meanwhile, there is such a demand for advice and assistance and the officials concerned are so overburdened with work, that it is worth considering whether the present system of employing a number of different agencies (mostly Government departments) for demonstration and teaching is the best, or whether, as in Italy, the employment of a single agency, charged with co-ordinating all the teaching to be given and in close contact with the individual cultivator, might not yield better results. The single-agency system would certainly be less bewildering to the simple-minded peasant, who must sometimes be puzzled by the number of his teachers. But whichever method is adopted, from our present point of view it is an advantage to the Punjab that the cultivator for the most

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[1] *Ibid*, p. 10.

[2] Colletti's estimate, based on the figures of the 1911 Census, is 18 millions (*La Popolazione Rurale in Italia*, 1925, p. 36); one million has been added on account of territorial additions made in 1919.

[3] Land dependent upon rainfall.

[4] In the farm at Gurdaspur 100 out of 160 acres are devoted to *barani* cultivation.

[5] Grants of Colony land have, however, been made in three cases on condition that fruit would be grown, and a certain amount of spade work has also been done at Lyallpur in connection with mangoes and figs.

part lives in villages and not in scattered farms as he generally does in northern and central Italy. The latter system by itself, no doubt, makes for better farming, but the former greatly facilitates demonstration, teaching and training, for in a village it is a comparatively simple matter to get people together. This is an advantage of which the fullest possible use should be made.

THE WORK OF THE CATTEDRE AMBULANTI.

A final word is necessary as to the work of the Chairs. The Director General of the organization, whom I had the privilege of meeting, claims for them that they have had a marked influence in four directions : fertilizers have been popularized, leguminous crops encouraged, modern ploughs and other improved implements introduced and cattle-breeding developed. Their influence has been most evident in the case of the first two. To take a single example, in twenty years the amount of artificial fertilizers used in Italy has risen from 100,000 to 1,400,000 tons. The war imposed a severe strain upon the staff, as it was everywhere depleted for military purposes, and the political and financial confusion that followed the war only made matters worse. The organization might have collapsed but for the financial assistance of the State. This, however, has led to another evil—excessive State control. "Every day," says Serpieri, "the Chairs tend to become more and more bureaucratic and lose the dynamic force which inspired them at first." They have not succeeded so well in the south as in the north. In some districts of the north -Siena is an example—they have worked miracles, but there are few, if any, cases of this in the south. This is partly because nothing in Italy fares quite so well in the south as in the north, and partly because the Chairs in the south have not been so well staffed, the best instructors preferring to serve in the north. Nor is it yet sufficiently known what is the best system of farming for the hotter parts of the country. Perhaps, the chief advanatge of a *Cattedra Ambulante* is that it provides in every district an organization, which automatically considers the farmer and his farm as a whole and not as a mosaic of different problems to be dealt with by separate departments independently of each other. A further advantage is that being a local organization it studies local conditions and draws attention to local needs. A good Chair will take on the colour of its environment and interest itself in the questions suggested by its surroundings. As such, it is a useful antidote both to the departmentalism of the expert and to the over-centralization of the State ; and being in close touch with the cultivator it realizes, what some are apt to forget, that the land exists for the peasant and not the peasant for the land.

ARTIFICIAL AND NATURAL ASIATIC-AMERICAN COTTON HYBRIDS.

BY

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III. THE NATURAL HYBRID ♀ 289 (G. HERBACEUM) × ♂ 182 (G. HIRSUTUM).

The main stem and branches. The main stem is about 100 cm. high; it is covered with a single layer of long, densely situated, hairs; it is about 1·1 cm. thick below and 0·8 cm. in the middle of the stem. The length of the internodes in the middle of the stem is about 6½ cm. The colour of the stem is green, but on the exposed parts it has a red tinge; the whole stem is profusely covered with very prominent gland-dots. On the lower part of the stem three monopodia arise from the accessory buds. The first main sympodium arises from the 4th node; the accessory sympodia begin from the 12th node; there are totally 20 main sympodia and 9 accessory ones. The sympodia are long with relatively long internodes; the first internode of the sympodium in the middle of the plant equals to about 1½ internodes of the main stem (about 9 cm.). The pubescence and colour of the sympodial branches are similar to those of the main stem. The development of shortened sympodia (bearing only one flower) from the accessory buds on the main sympodia takes place very frequently.

The leaves along the main stem are the most developed, they are 7-lobed. The central lobe is ovate with a pointed tip and is about half as long as the main vein. The surface of the leaf is slightly ondulated. The base of the leaf is broadly and deeply (about 2 cm.) cordate. The dimensions of the leaf-blades in the middle of the main stem are 10 × 12 cm. The leaves are comparatively densely coated with short hairs on the upper side, and somewhat more densely coated with hairs on the lower side. The lamina is green coloured, the " nerve-knot " is reddish, the nerves are green. There are about three nectaries on the leaves of the main stem, while on the sympodial branches there is only one nectary; the nectaries are relatively small (about 1½ mm.) of a rounded shape. The petiole is somewhat shorter than the leaf-blade, it is covered with a rather dense single layer of long hairs, with a reddish tinge on the exposed parts. The stipules on the main stem are lanceolate-crescent shaped (17 × 4½ mm.) from outside and on the margins they are covered with medium short hairs; they are green coloured with a reddish tinge.

The flower is medium sized, the petals considerably exceeding the involucrum, uniform, with a medium-sized, well-developed vexillum; they are bright-yellow coloured (but paler than ♀ 289) with a well defined crimson spot (10 × 8 mm.); a smaller crimson spot is present on the outer side of the petals. The anthers and the pollen are yellow (of an intermediate tinge between ♀ No. 289 and the Upland); the pollen, when examined under a microscope, is abnormal, in most cases semi-spherical in form. The stamens are pale-yellowish; the lower ones are slightly red tinged. The stigma projects from out of the stamens, it consists of 4 closely united parts. The calyx is crenulate at the margin; the crenatures are triangular, short, with medium dense hairs on the margins; it is red coloured (but paler than that of the ♀ No. 289) with very prominent gland dots. The bracts are united (the junction is about 5-10 mm. long), dissected into about 13 teeth of medium length; the central tooth is as long as ⅓ of the main nerve; from outside they are rather densely covered with medium sized hairs, that are hardly reaching the inner side; they are green coloured, with a reddish tinge on the exposed parts. There are no outer extra-floral nectaries, the inner ones are present in several flowers 1—3 in each, they are of a rounded shape, about 1½ mm. long, sometimes smaller, with medium sized dense hairs. There are no hairs at the inner ring of floral nectaries.

The peduncle is short with comparatively densely situated hairs, green coloured and red on the exposed parts. The ovaries fall off soon after blooming. The plant is completely sterile.

IV. THE NATURAL HYBRID ♀ 3258 (G. HERBACEUM L.) × ♂ 182 (G. HIRSUTUM L.).

The main stem and branches. The main stem is about 120 cm. high and 2 cm. thick in its lower part. It is covered with a single layer of long dense hairs. The colour of the stem is dark-red on the exposed parts and green on the opposite parts, with minute gland dots. There are 4 monopodia on the lower part of the stem, arisen from the main buds, and 12 monopodia, situated above them, developed from the accessory buds. Only one of the main monopodia is strongly developed, the others are short and do not exceed the sympodia in length. The main sympodia (22 in number) begin from the 4th node; the accessory well-developed sympodia (more than 6 in number) begin from the 16th node. The sympodia are rather long with relatively long internodes; the first internode of the sympodium (in the middle of the plant) equals two internodes of the main stem.

In respect to the pubescence and colour, the sympodial branches are similar to the main stem, which is dark-red on the exposed parts and possesses only long hairs. The accessory branching of the main sympodia results in the formation of shortened sympodia from the accessory buds.

The leaves all along the main stem are 3—5 lobed (near the fourth sympodium), sometimes more; the central lobe is ovate-triangular and is a little longer than a half of the main nerve. The surface of the leaf is slightly ondulated. The base

of the leaf is broadly and deeply cordate. The leaf-lamina is covered with short hairs more densely situated on the lower side ; it is green coloured, but the " nerve-knot " is reddish. There are 1—3 nectaries of medium size and of a roundish-oblong shape. The petiole is as long as the lamina and is covered with long hairs, dark-red on the exposed parts. The stipules are crescent-shaped ; medium sized ; densely coated with minute hairs ; red on the exposed parts and green on the opposite parts.

The flower is medium sized, a little larger than ♀ No. 3258 ; all the petals have a well developed vexillum and are yellow, but of a paler tinge than ♀ No. 3258, with a *small*, crimson coloured, spot. The anthers and the pollen are yellow ; the pollen is abnormal, often semi-spherical in shape. The stigma projects distinctly from the stamens and consists of 4—5, closely united parts. The calyx is ondulated at the margin, consisting of 5 rounded crenatures ; it is green with minute but prominent gland dots. The bracts are slightly united at the base, dissected into 11—13 teeth (the central tooth equals $\frac{1}{3}$ of the whole length of the main vein); from outside they are covered with comparatively short hairs, and are green with some red tinge on the exposed parts. There are no outer extra-floral nectaries ; the inner ones are triangular or oblong in shape, comparatively small and profusely coated with hairs. The peduncle is of medium length, with long hairs, green, with some reddish tinge on the exposed parts. The ratio of the long successions in blooming to the short ones is 2 to 5, thus the process of blooming reveals a perfectly normal development of the plant. The ovaries fall off soon after blooming. *The plant is completely sterile.*

♀ 3258. *G. herbaceum L.*

The main stem and branches. The main stem is about 120 cm. high and about $1\frac{1}{2}$ cm. thick at the base. It is coated with a double layer of hairs, long and short ones, very densely situated. It is reddish coloured on the exposed parts and green on the opposite parts, with bright, minute, gland dots. There is only one small sized monopodial branch developed from a main bud, at the base of the stem. The main sympodia (22 in number) begin from the third node, the accessory sympodia (12 in number) from the 8th node. The sympodia have rather long internodes (the length of the first internode equals to $1\frac{1}{2}$—2 internodes of the main stem). The pubescence and colour of the sympodial branches are the same as those of the main stem. Shortened secondary sympodia are often developed from the accessory buds of the sympodia. The metamorphosis of the terminal bud into a monopodium can be noticed.

The leaves all along the main stem are 5 to 7-lobed with an ovate central lobe tapering to the base, the length of the central lobe equals 0·6 of that of the main vein. The surface of the leaf is often ondulated. The base of the leaf is broadly cordate. The leaf-lamina is medium sized ; it is densely covered with short hairs on both sides ; along the veins the hairs are somewhat longer. The leaf-blade

and " nerve-knot " are green coloured. There are 1—3 small nectaries of a roundish or horse-shoe shape. The petiole is as long as the leaf-lam na and is covered with a double layer of hairs, with a redd sh tinge on the exposed parts. The stipules are lanceolate-crescent shaped, relatively small, densely covered with minute ha:rs, green.

The flower is medium sized, the petals are not uniform (with and without a vexillum), yellow with a bright-crimson petal spot. The anthers and the pollen are bright-yellow. The stigma hardly projects from the stamens and consists of 3—5 closely united parts. The calyx is ondulated at the margin (with 5 rounded crenatures), without hairs, green, with bright glands. The bracts are closely united at the base, dissected into 9—11 teeth; the central tooth equals ¼ of the length of the main vein; on their outer side and partly on the inner side the bracts are densely covered with minute hairs; green, with a reddish tinge on the exposed parts. There are no outer extra-floral nectaries, the inner ones are triangular, rather large, densely covered with very short hairs. There are evidently no hairs at the inner ring of floral nectaries. The peduncle is of a medium length, with dense-short and long-sparse hairs; it is green coloured. The boll is spherical, it is as long as broad, green, with a smooth surface, 5-locular, drooping when ripened. It is slightly dehiscing, but the valves open almost perfectly. The lint is white, distributed all over the whole seed (about 25 mm. in length). The seed is medium-sized, profusely coated with a white (pale-greenish at fading) fuzz.

V. The natural hybrid ♀ 454 (G. herbaceum L.) × ♂ 182 (G. hirsutum).

The main stem and branches. The main stem is about 120 cm. high and about 1½ cm. thick below. It is covered with a single layer of long hairs and is dark-red coloured on the exposed parts, and green on the opposite parts where minute gland dots are present. On the lower part of the stem is one monopodial branch developed from a main bud, and more than 10 monopodia arising from accessory buds; the accessory monopodia are of moderate development. The lower monopodia are somewhat longer than the sympodia; the upper ones are half the size. The ma n sympodia (25 in number) begin from the 5th node; there is only one accessory sympod um. The sympodia are rather enough with relatively long internodes; the first internode of the sympodium in the middle of the plant equals two internodes of the main stem. The pubescence and colour of the sympodial branches are similar to those of the main stem. The accessory branching of the sympodia results in the development of shortened sympodia from the accessory buds. The metamorphosis of the terminal (flower) bud into a monopodium partly may be noticed (at the 11th sympodium).

The leaves all along the main stem are five-lobed, on the upper part of the stem they partly develop a sixth lobe. The central lobe is triangular-ovate (with some contraction in the lower part); its length equals 0·6 of the length of the main vein.

The surface of the leaf, except its usual folds, has some ondulations resembling those of the female parent form ; the base of the leaf is deeply but rather narrowly cordate, so that the edges of the cordature partly cover one another. The leaves are covered with dense short hairs, which are somewhat shorter on the lower side. The leaf-lamina is green, the "nerve-knot" is red, but its colour is paler than that of the Upland. There are 1 to 3 nectaries, rather small, of a roundish horse-shoe shape. The petiole is as long as the lamina and is covered with long hairs of a moderate density ; it is dark-red on the exposed parts. The stipules are crescent-shaped, rather small, with short hairs, reddish on the exposed parts.

The flower is medium sized ; the corolla being one and a half times as long as the involucrum ; the petals have a well developed vexillum and are pale-yellow coloured with a medium-sized dark-crimson spot at the base ; the spot is variable : thus, the flowers of two sympodia have no spot at all, while on the other branches it is present. The anthers and the pollen are yellow ; the pollen is abnormal. The stigma projects from the stamens, consisting of 4 closely united parts. The calyx is ondulated at the margin, consisting of 5 rounded crenatures, green with minute. but very prominent gland dots. The bracts are slightly united at their base, dissected into 13—15 teeth ; the central tooth equals one-third of the main vein ; on the outside the bracts are covered with short hairs ; they are green in colour—pink on the exposed parts. There are no outer extra-floral nectaries ; the inner ones are of a triangular or rounded form, rather small, densely covered with short hairs. An abundant effusion of nectar is noticeable. The inner ring of floral nectaries has a rather large number of hairs. The peduncle is medium sized and is relatively densely covered with long hairs, green with some red tinge on the exposed parts. The ratio of the long successions of blooming to the short ones, on the average, is as 2 to 5 and thus the process of blooming reveals a perfectly normal development of the plant. The ovaries fall off soon after blooming. *The plant is completely sterile.*

VI. The natural hybrid ♀ G. herbaceum L. × ♂ G. hirsutum L.

The main stem and branches. The main stem is about 90 cm. high. It is covered with a single layer of long, rather dense, upright hairs. The colour of the stem is dark-red on the exposed parts and green on the opposite ones, with slightly prominent gland dots. There are 4 monopodia on the lower part of the stem, developed from the main buds, one of them is medium sized, while the others are short. The main sympodia (19 in number) begin from the 5th node. The accessory buds have not been developed. The sympodia are rather long with long internodes ; the first internode of the sympodium in the middle of the plant equals two internodes of the main stem. In respect to the pubescence and colour the sympodia are similar to the main stem. There was no accessory (secondary) branching on the sympodia. (The plant was grown on relatively poor soil.)

The leaves along the main stem are 5-lobed ; the central lobe is triangular-ovate shaped and equals to 0·6 of the main nerve. The surface of the leaf is slightly ondulated (except the usual folds). The base of the leaf is broadly and deeply cordate. The leaf-lamina is covered with short hairs which are somewhat denser on its lower side ; along the nerves on the lower side the hairs are somewhat longer. The leaf is green coloured, the " nerve-knot " is red, the nerves have a pale-reddish tinge. There is one nectary of a rounded form, rather small. The petiole is as long as the leaf-lamina, bright-red on the exposed parts and comparatively densely covered with long hairs. The stipules are lanceolate-crescent shaped, medium sized, densely covered with minute hairs and bright-red in colour.

The flower is medium sized ; the petals possess a well developed vexillum, pale-yellow coloured with a dark crimson spot at the base, they are of medium size (but smaller than those of *G. herbaceum*). The anthers and the pollen are yellow. The stigma projects from the stamens and consists of 4 closely united parts. The calyx is ondulated at the margin, (roundish crenulated) with sparsely situated hairs, green coloured. The bracts are united, dissected into 13 teeth ; the central tooth equals to ⅓ of the main nerve ; from outside they are covered very profusely with moderately short hairs, and are green coloured, with a pink tinge on the exposed parts. There are no outer extra-floral nectaries ; the inner ones are rounded, small, pubescent. The peduncle is medium sized, green, with a red tinge on the exposed parts. The plant is completely sterile.

VII. THE NATURAL HYBRID ♀ 454 (G. HERBACEUM L.) × ♂ 182 (G. HIRSUTUM L.).

The branching. Main monopodia—4 ; accessory—4.
Main sympodia—4 ; accessory—1.

The height of the first sympodium—6 (*i.e.*, the first sympodium arises from the 6th node).

The length of the internodes of the main stem = 17 cm. : 3=5·7 cm. The hairs along the stem are single layered, long, rather scarce. The sympodia are of continuous growth, with long internodes (about 2 cm.).

The leaves along the stem are 5—7 lobed, about 9·1 cm. long. The central lobe is ovate, tapering to the base, it is 4·2 cm. long, that is, it equals to the main nerve. The 6th and 7th lobes are hardly noticeable (being one-tenth of the length of the veins). The margin of the leaf is ondulated. The base of the leaf is moderately deeply cordate, with a broad cordature. The leaf is green coloured. The nerve-knot has an anthocyanin tinge, but there are no traces of anthocyanin tinge along the nerves. There are 3 nectaries. The hairs are short on the upper side of the leaf and somewhat dénser below. The petiole is as long as the leaf-lamina.

The flower. The petals are of a normal form, with ⅓ exceeding the involucrum. They are yellow coloured with a small pale spot. The staminal column is medium sized, the dehiscence of the anthers is abnormal, the stamens are of medium length.

The stigma is medium sized, consisting of 5 closely united parts. The calyx is crenulated, with rounded crenatures, hirsute at the margin, green. The dimensions of the bracts are 2·7 × 2·5 cm., the junction is moderate, the number of teeth is 14—15, the central tooth is one-third the length of its vein ; the bracts are green with a pale-anthocyanin tinge, hirsute. There are no outer extra-floral nectaries, the inner ones are either medium-sized and rounded or small and hirsute ; often they are absent. The inner ring of floral nectaries has no hairs. The peduncle is short. The ovary is egg-shaped (of the Upland type). *The plant is completely sterile.*

General conclusions concerning the inter-species hybrids.

The observations on the young seedlings of the two artificial hybrids soon after the appearance of the cotyledons on the surface, show that the hybrids differ considerably from the female parent by the entire absence of hairs on the hypocotyl (II) and on the petiole of the cotyledons, as well as by the presence of long sparsley situated hairs (I), thus revealing their hybrid origin in the very first stages of their growth since ♀ 454 and ♀ 455*a* have very short hairs on the hypocotyl. In view of the presence of short hairs on the female parent and their absence on the male parent, the observation of this character serves as a good criterion for the determining of the artificial and natural hybrids.

The anthocyanin tinge of the " nerve-knot " of the cotyledons may be also considered as a peculiar characteristic feature of the hybrids. The fully-developed hybrids show a considerable number of characters that are intermediate or approaching the male parent type, thus determining definitely their hybrid nature. Of the most prominent characters we shall point out the following :

In distinction to the female parent (*G. herbaceum* L.) which has a double-layered pubescence (consisting of short and long hairs) along the stem, branches and leaf-petioles, all the hybrids show only a single layer of either long or medium-long hairs and in this respect they approach to the male parent type.

The exposed parts of the main stem, branches, leaf-petioles and " nerve-knots " of the hybrids have a pronounced anthocyanin tinge and in this character also the hybrids approach the male parent type. A characteristic peculiarity of the hybrid leaves is an ovate (oblong) form of the central lobe and of the other lobes, with a pronounced tapering at the base, which is very characteristical of *G. herbaceum* L., although this feature is softened in the case of hybrids. Thus, the lobe character shows the intermediate position of the hybrids. This intermediate position is also emphasized by the number of the leaf-lobes. Some interesting peculiarities are manifested in the flowers. Differing from the female parent type, the hybrids in most cases show entirely loose bracts, not at all united, like those of the male parent type. The character of the teeth of the bracts is intermediate. The calyx of the hybrid ♀ 289 had a red tinge resembling in this the female parent. The outer extra-floral nectaries (situated under the bracts in the upper thickened part of the peduncle)

were absent in all the hybrids, as well as in the male parent itself, but the inner extra-floral nectaries situated at the base of the calyx (amidst the bracts) were present in all the flowers ; they were of a rounded or triangular form with hairs and of visibly smaller size than those of the female parent. The inner ring of floral nectaries (inside, at the base of the calyx) possessed hairs in most of the hybrids (5) in distinction from the female parent ; only in two of the hybrids (II and III) have hairs of the inner ring of floral nectaries not been revealed. Thus, taking into consideration the character of the floral and extra-floral nectaries, the hybrids partly resemble the female parent type (in the presence of the inner and absence of the outer extra-floral nectaries) and partly resembling the male parent type (in the hirsuteness of the inner ring of floral nectaries). In distinction from the female parent type all the petals are uniform with a well developed vexillum ; they are yellow-coloured, distinctly paler than those of the female parent ; sometimes the petals possess a dark-crimson spot ; sometimes this spot is absent. This character, in general, shows a very curious behaviour. The hybrid I had all the flowers spotless ; only 3 branches gave spotted flowers ; on the contrary, the hybrid II showed all its flowers with spots on their petals, and the spots were very bright and so similar to those of the female parent, that even a small spot-let could be recognized on the outside of the petals.

The natural hybrids have also showed some duality in this respect : in most cases the petals of their flowers had a spot, but some separate branches bore spotless flowers. It must be noticed that the presence and absence of petal spots was uniformly manifested along the branches : a branch either had all flowers with spots, or they were all spotless. All the hybrids had yellow anthers and pollen, resembling in this case the female parent type. The pollen of all the hybrids was abnormal, often semi-spherical, as if crushed ; the contents of the pollen grains was often clod-like (when examined under a microscope, by means of passing light), when put into water the hybrid pollen rarely swells and bursts ; it was completely sterile as were the ovules. Neither in the case of self-pollination, nor in the case of artificial cross-pollination with the pollen of different parental and non-parental forms of cotton, do the hybrids set fruit ; they always remain completely sterile.

The general conclusions deduced from the examination of the available data may be as follows : although under some exceptional conditions we are able to obtain artificial and natural hybrids of *G. herbaceum* L. with *G. hirsutum* L., in view of their complete sterility, they are useless.

In connection with this, the hypothesis which has been often proposed (by G. Watt and others) concerning the mutual influence of these two species of cotton, must be ultimately abandoned.

CROP AND WEATHER DATA IN INDIA AND THEIR STATISTICAL TREATMENT.

BY

S. M. JACOB, I.C.S. (RETD.)

Part I.

INTRODUCTION.

THE broad problem of the determination of the total crop produce of any country resolves itself into two distinct subsidiary problems, firstly the determination of the area sown with each type of crop and then of the yield of each crop per unit of area. Where, as in many European countries, the area of land sown to different crops has a small amount of variation and that mostly of a secular character referable to economic causes, such as the migration of labour or a change in relative prices, the dependence of the area sown on meteorological conditions is apt to be obscured. The result has been that attention in Europe and even in America has been drawn chiefly to determining the effect of weather on the growing crop—a problem of plant reaction to meteorological environment—rather than to the almost equally important problem for India of the human reaction to weather conditions which determines the area which the cultivator will sow to the various kinds of crop.

Thus Sir A. D. Hall has summed up the nature of the first problem in an article in the " International Review of the Science and Practice of Agriculture "[1] in which he says : " This broadly is the field of Agricultural Meteorology, ultimately to predict crop yields from the weather prevailing during their growth."

AGRONOMIC METEOROLOGY.

While retaining, therefore, the title of agricultural meteorology for the problem thus delimited by Sir A. D. Hall, it is necessary to emphasize the distinct problem of the effect of weather on the area sown and I propose to call the subject of this problem Agronomic Meteorology.

AGRONOMIC METEOROLOGY A BRANCH OF AGRONOMICS.

Viewing the matter more particularly from an Indian standpoint we may say that the task of Agronomic Meteorology is to examine the effects of climate and

[1] Hall, Sir A. D. Agri. meteorology as a field for investigation. *Int. Rev. of the Sci. and Practice of Agri.*, N. S., I, No. 2 ; April-June 1923.

weather on the area sown to different crops, the intermediate links being the effects of climatic conditions on the area of land available for the plough, the effects of climate and weather on the physical condition of the soil and the human estimate of that condition, and on the energy of man and beast in carrying out agricultural operations. Thus Agronomic Meteorology will be a small branch of Agronomics proper which will have in itself a good deal to say on the subject of the effect of forms of land tenure, indebtedness of the agricultural population, and above all on the effect of varying price levels on the areas of land which are sown to different crops. While, therefore, Agronomic Meteorology will concern itself particularly with the direct effect of rainfall, temperature, sunshine and winds in inducing the cultivator to bring varying amounts of unirrigated lands under the plough, or of increasing or restricting[1] his use of artificial sources of irrigation, it will, nevertheless, be forced to take account of Agricultural Economics generally, and the investigator will have to be on his guard against correlating with changes in the rainfall, say, the area sown to wheat, without having regard to the variations in wheat prices at sowing times as compared with prices of other foodstuffs.

Again, the effect of population, both human and bovine, on the areas sown in different regions is necessarily very marked, and these populations in their turn are dependent on the distribution of favourable climatic conditions. A striking example of the dependence of population on rainfall is afforded by the general correspondence of the lines of population density in the pre-colony days in the Punjab with the isohyets or lines of equal (annual) rainfall.[2] Where, as in North-West India, canal irrigation has been highly developed, the effect of rainfall will have to be considered in its relation to the water-supply at the head works, in relation to the " duty " or acreage of crops per cusec discharge, and in certain alkali-ridden or waterlogged areas, in relation to the definite diminution of the area of culturable land.

It is apparent, then, that Agronomic Meteorology is confronted by a very heavy task.[3]

RELATIVE IMPORTANCE IN ESTIMATES OF CROP-PRODUCTION OF AGRONOMIC AND BIOLOGICAL VARIATIONS.

In many countries there is so little variation in the area under different crops or in the totality of crops from year to year that the meteorologist is inclined to

[1]This effect of rainfall in diminishing the use of irrigation water is a first order effect and a high correlation has been obtained (Jacob, S. M. Correlation of rainfall and the succeeding crops with special reference to the Punjab. *Mem. Ind. Met. Dept.*, XXI, Pt. XIV, 1916). Small wonder that this should be so, as setting aside the additional labour involved in artificial irrigation the Indian cultivator compares well-water to goats' milk and rain-water to mothers' milk.

[2]Middleton, L. M., and Jacob, S. M. *Census of India*, 1921, Vol. XV—Punjab and Delhi, Pt. I, pp. 110-111.

[3] Descriptive has to precede quantitative analysis, and no statistician can safely work at the problems of Agronomic Meteorology without a clear grasp of the complications of rural economics. For the Punjab the works of Calvert (*Wealth and Welfare of the Punjab*) and Darling (*The Punjab Peasant in Prosperity and Debt*) serve this purpose well.

think that his forecasts are valuable only because they enable the farmer or trader to visualize the effects of weather on the growing crops, and the significance of the weather in determining whether the crops are ever sown at all is apt to be lost sight of.

In India the variations in the areas sown are hardly less considerable than the variations in the yield per acre, and that both are important is shown by the following figures for the area and yield of wheat for the Punjab for the 24 years 1899-1922. To eliminate the effect of secular change the period is divided into two groups of 12 years each, *viz.*, 1899-1910 and 1911-1922 :

Punjab wheat (British India only).

Year	Yield in millions of tons	Area in millions of acres	Yield per acre in tons
1899	1·77	6·96	0·25
1900	1·67	5·68	0·29
1901	2·62	7·67	0·34
1902	1·83	7·23	0·25
1903	2·30	6·99	0·33
1904	3·06	7·77	0·39
1905	2·84	7·71	0·37
1906	3·50	8·57	0·41
1907	2·63	9·65	0·27
1908	2·21	7·39	0·30
1909	3·00	8·40	0·36
1910	3·27	8·68	0·38
AVERAGE 1899-1910	**2·56**	**7·72**	**0·33**
1911	3·29	8·88	0·37
1912	3·37	9·72	0·35
1913	2·86	8·77	0·33
1914	3·21	8·47	0·38
1915	3·16	9·92	0·32
1916	2·17	8·99	0·24
1917	2·56	9·47	0·27
1918	3·00	9·93	0·30
1919	2·61	7·68	0·34
1920	3·40	8·81	0·39
1921	2·03	7·47	0·27
1922	3·64	8·79	0·41
AVERAGE 1911-1922	**2·94**	**8·91**	**0·33**

The amount by which the figures of area and of yield per acre vary from year to year is shown by the coefficient of variation, which shows the percentage amount by which, on the average, the yearly figures differ from the mean of each of the group of years. These are as follows :—

Coefficients of variation of area and yield per acre for Punjab wheat.

Years	For area sown in acres	For yield per acre in tons
	Per cent.	Per cent.
1899-1910	12·6	16·1
1911-1922	8·5	15·4

Thus for wheat in the Punjab there is certainly a greater variation in average yield per acre from year to year than there is in the year to year area sown to wheat, yet the variations of the areas sown are very considerable and it is important to determine the causes which produce such variations in area and to estimate the change in advance from known (or forecasted) economic and meteorological conditions. This is the function of agricultural economics and will be that of agronomic meteorology in particular.

In the data just given for wheat, unirrigated and irrigated soils have been taken together, but as we naturally expect the variation in the areas of unirrigated crops greatly exceeds that for the lands whose crops are stabilised by the presence of wells or of perennial or even short-term canals. Thus for the twenty years 1901-1920 (inclusive) the average irrigated area of sown crops in the Punjab was 11·29 million acres, with an annual variation of 8·8 per cent., while the unirrigated crops averaged 16·45 million acres with an annual variation of 17·5 per cent., or nearly exactly double the variation on irrigated areas. For unirrigated areas then the problems of agronomic meteorology become more important than ever.

If we take the figures for the whole of India[1] the annual variation of the area under wheat, 10·3 per cent., actually exceeds, if the figures are accurate, the variation in the average yield per acre, which is only 7·8 per cent. for the 13 years 1909-1921 (inclusive).

Though the figures for yield are open to doubt, as we shall note later on, at any rate they suggest that taken as a whole the problem of the determination of the area sown affects the final result—the total yield of each crop—to the same general extent as the yield per unit of area. Thus for India, at any rate, the sciences of agronomic and agricultural meteorology are equally important.

[1] *Int. Year-book of Agri. Statis.*, 1909-1921, pp. 34, 35, 38, 39.

Statistics of sown areas.

From the meteorologist's view-point, therefore, there are two peak problems in surmounting which he can afford help to the agriculturist. These I have ventured to distinguish as the problems of (1) agronomic and (2) agricultural meteorology, respectively, and the foregoing considerations have been adduced to show that the two problems are of co-ordinate importance if the total crop yield of a district, of a province, or of the whole of India is to be determined.

It is now necessary to consider to what extent Indian agricultural statistics are reliable, and if so to what extent they are relevant to the issues raised by these two problems. The general method of collating statistics of area and crop yield in India have been described by Rai Bahadur D. N. Ghosh[1] and his statement that " there exists .. an agency capable of reporting the acreage of crops with great accuracy, wherever fields have been mapped and surveyed", is guarded and correct. Speaking only of the conditions of which I have first-hand knowledge, I say without hesitation that the areas of the various crops in the Punjab are recorded, so far as sown areas are concerned, with an error of probably less than 2 per cent. and possibly as little as 1 per cent. This accuracy will only apply to the totality of the sown areas in each village or to those crops which are sown singly : when mixed crops, such as wheat and gram or barley and gram, or strips of hemp on the borders of a sugarcane field, are recorded, the revenue agency has to guess the proportion of each crop, and it is doubtful whether errors of 10 to 20 per cent. or more are not made in many cases for individual fields, though these errors may not affect district or tehsil totals to the extent of more than 5 per cent. for each individual crop. It may be noted, too, that as the total sown areas are very accurately known for each village, the excess area assigned to one crop will be offset by a defect in area assigned to the crop with which it is grown. Thus in seeking for the traces of causation between meteorological factors and areas of crops, we can count on very accurate figures of the latter (except for permanently settled tracts such as Bengal) though we must be prepared for possible errors of as much as 5 per cent. in the areas of individual crops which are grown mainly or largely as mixed crops.

The first task of agronomic meteorology.

In its theoretical aspects Agronomic Meteorology should no doubt consider all the effects that variations of climate and weather have on the economics of agriculture.

In the first instance, however, and for sternly practical and utilitarian objects, Agronomic Meteorology should concern itself with the broad problem of determining the exact way in which rain, temperature, humidity and sunshine at different times affect the area sown at each harvest. The total areas sown and more particularly the areas sown to each kind of crop are the desiderata.

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[1] Ghosh, D. N. Crop reporting in India. *Agri. Jour. India*, XIX, Pt. 5, Sept. 1924.

In mathematical language the effect of meteorological conditions on sown areas is a first order effect, but there will be many effects of the second order, which might vitiate conclusions unless they were taken into account.

Unirrigated land.

The leading case is the effect of rainfall on sowings in unirrigated areas. For example, the writer[1] has found that August, September and October rainfall all increase the sown area of wheat in the Dona Charhda Circle of the Jullundar District in the Punjab, the effect of 1″ of rain in October being equivalent to that of 5″ in September and to no less than 18″ in August. If we multiply the actually occurring rainfall by $\frac{1}{18}$, $\frac{1}{5}$ and 1 for the month of August, September and October respectively and then compare the total " weighted " rainfall with the sown areas of wheat, a fair correspondence is found which is expressible by a simple formula. Yet we must clearly examine the discrepancies more closely by examining (1) the rainfall in finer groupings, say of weekly divisions, (2) the temperature, (3) the subsoil moisture and (4) grain-prices, both as affecting the purchase of seed and the promise of profit. All these factors immensely affect the practical farmer and determine the area which he sows to a particular crop.

Well-irrigated land.

In a great part of India irrigated and unirrigated land are found in the same village and the problem of Agronomic Meteorology becomes an extremely nice one, as favourable weather means additional sowings on unirrigated soils but throws out sowings which depend on irrigation. For example, the following effects of an inch of rain above the average on wheat-sowings have been found for the Dona Charhda Circle for the years 1886-1915 inclusive :—

An additional inch of rain above the average in	Adds to the unirrigated sown area of wheat		Diminishes the well-irrigated area of wheat by	
		Percentage*		Percentage*
August	630 acres	1·4	570 acres	3
September	2,300 „	5	750 „	4
October	11,400 „	25	4,300 „	23

[1] Jacob, S. M. Correlation of rainfall and the succeeding crops with special reference to the Punjab. *Mem. Ind. Met. Dept.*, XXI, Pt. XIV, 1916.

* These are percentages on the average unirrigated and average well-irrigated sown areas for the Assessment Circle.

On balance the additional rain is (in general) favourable to increased sowings, but the relationship is by no means a simple one, and for rainfalls which differ much from the average the above figures would have to be considerably modified.

CANAL IRRIGATED LAND.

The same phenomenon of the diminution of irrigated areas of crops with favourable weather conditions is well realized by canal engineers. The converse effect of the increase of canal-irrigated crops with diminishing rainfall is a limited one, as there comes a stage when there is insufficient rainfall to give a full discharge to the canals. The following problems of Agronomic Meteorology are important for canal-irrigated lands :—

(A) What is the quantitative law connecting weather conditions with the areas of (1) irrigated, (2) unirrigated crops in "commanded" tracts ?

(B) What are the optima weather conditions for a high "duty" in the spring and autumn harvests ?

There is a vast store-house of valuable statistics in the records of the Irrigation Department,* and much expert knowledge too among the individuals of the department. But statistical sifting is needed, and the figures should be studied from the viewpoints of meteorology and agricultural economics.

Part II.

AGRICULTURAL METEOROLOGY.

I trust that it is clear that the sphere of Agronomic Meteorology is entirely distinct from that of Agricultural Meteorology. The former is concerned with the weather conditions which induce the cultivator to plough and sow land or to refrain from ploughing and sowing it or affect his capacity to do these things ; the latter science has to deal with the problem of the reactions of the plant, once the seed is sown, to the weather conditions, whether these are represented by the integrated effects of rain and sunshine and so forth prior to seeding, or to the meteorological factors current during growth. A very considerable literature has sprung up on the subject since R. H. Hooker—the pioneer in applying to the problem the method of correlation—investigated the subject in 1907[1]. The method of correlation is by no means the only way of attacking this problem even from the statistical side, but its vitality is shown by the remarkable series of coefficients obtained in a further research by Hooker[2] in 1922. The sequences of the same sign for the coefficients

* In particular I have in mind the series of records of all agricultural operations on selected outlets of the Punjab perennial canals, which was drawn up under the orders of Mr. Woods, then Chief Engineer, Punjab.

[1] Hooker, R. H. *Jour. Roy. Statis. Soc.*, dated 15th January 1927.

[2] Hooker, R. H. *Jour. Roy. Met. Soc.*, XLVIII, 1922.

of 8-weekly periods associating the yield and the rainfall and temperature are at least as striking as the absolute magnitude of these coefficients. The following table shows the actual number of ' runs ' of the same sign of partial correlation coefficients obtained by Hooker and the number of ' runs ' which we should expect if chance alone were at work.

' Runs ' in the sequence of sign in correlation coefficients found by R. H. Hooker in 1922.

Runs of length	*2*	*3*	*4*	*5*	*6*	*7*
Yield and rainfall	8	1	4	4	0	1
Yield and temperature	13	5	5	0	2	1
Yield and " spurious " causes	12	5·5	2·5	1·1	0·5	0·2

The occurrence of long ' runs ' of the same sign in the sequences of 8-weekly co-efficients for the dependence of yield on rainfall and temperature differs markedly from expectation if chance alone had determined the ' runs,' and we are clearly in touch with true causation.*

What the method of correlation may effect is further emphasized by workers in America. J. Warren Smith,[1] who has been a worker in this field since 1911, has recently determined a " weather index " of factors injurious to plant growth, and finds a correlation between that index and the yield for oats, maize and cotton which exceeds 0·9 in absolute value.

Other methods are now being evolved, notably by R. A. Fisher[2], and he has undoubtedly put his fing.r on a weak spot in the method of correlation.†

However, there is no need now‡ to defend the application of statistical methods to the problems of agricultural meteorology, as its value has been recognized by such authorities as Sir A. D. Hall (*loc. cit.*) and Sir E. J. Russell[3]. The point that is one of concern is as to how far Indian statistics are going to throw light on the connection of weather conditions and yield.

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* Pearson's test of ' goodness of fit ' (if it is applicable to such cases of discrete frequency) shows that the odds against such " runs " being due to chance are over 7,000 to 1 against for the rainfall co-efficients and over 17,000 to 1 against for the temperature co-efficients.

† Namely that as you correlate yield with finer and finer time divisions of rainfall or what-not, the co-efficients tend towards zero.

‡ Various workers in India have now applied statistical methods to elucidate the results of crop experiments, of whom F. R. Parnell for data for Coimbatore (*Agri. Jour. India*, Oct. 1919), O. T. Faulkner for Lyallpur (*Agri. Jour. India*, Sept. 1921), and B. N. Sarkar (*Agri. Jour. India*, Sept. 1923) and P. C. Mahalanobis (*Agri. Jour. India*, March 1925) for Kanke are the most notable. Things were different in India in 1916.

[1] Smith, J. Warren. Influence of weather on the yield of crops. *Mon. Weather Rev.*, No. 50, Pt. II, pp. 567-572, 1922.

[2] Fisher, R. A. The influence of weather on the yield of wheat at Rothamsted. *Phil. Trans. Roy. Soc*, Series B, Vol. 213, 1924.

[3] Russell, E. J. Present day problems in crop production. *Agri. Jour. India*, Jan. 1925.

OFFICIAL STATISTICS OF YIELD.

The main sources of yield data in India are—

(a) Records of crop experiments, carried out by the Government revenue staff, during settlement operations and during the routine of district administration.

(b) Records of "failed" crops, which are noted by the village revenue agency from a field to field inspection of the standing crops just before harvesting. These records are available for about 30 years in the Punjab for most of the principal crops and for a longer period for groups of crops, such as well-irrigated, canal-irrigated and un-irrigated crops in certain districts.

(c) Records of Agricultural Department experiment stations.

(d) In addition, reference should be made to the official Season and Crop Reports, which give the estimates of yield of some important crops, such as wheat, sugarcane and cotton, prepared by Directors of Agriculture or Land Records on reports furnished by the local revenue and agricultural officers, modified by the former according to their individual judgment.*

VALUE OF INDIAN CROP YIELD DATA.

As to (a), I tried some years ago to collate data but found the series very incomplete. Further the district figures of yields are mostly intelligent guesses of what the Naib-Tahsildar thinks will meet with official and local approval. A rather careful crop experiment carried out in the Delhi District was turned down by the Deputy Commissioner because the yield was, in his opinion, impossible. Few district officers would critically examine, much less supervise, the actual experiment, unless they had been Settlement Officers. The results of crop experiments made during settlements would repay closer examination, but even these would only give a discontinuous series.

As to (b), the data, if cautiously handled, would give some useful quantitative results. In one case the "failed" area was found to have a correlation of 0·91 with the antecedent distribution of rainfall. If, however, these data were worked

* As individual judgments differ, this definitely prevents the provincial estimates of output being comparable over a series of years, and it by no means follows, as has been sometimes assumed (Trevaskis, H. K. Wheat forecasts in the Punjab. *Agri. Jour. India*, May 1924) that the percentage error is of the same sign, much less of the same magnitude from year to year. Thus for the estimates of yield of wheat, cotton and sugarcane for which I was responsible for three years as Director of Agriculture (Punjab) I adpoted a method of smoothing by drawing the isopleths of yield (one series for irrigated and another for unirrigated crops) on a fairly large scale skeleton map of the province. Whether this method led to estimates of yield nearer the truth (as I anticipate) or not, it undoubtedly differed from the method adopted by my predecessors. Similarly the methods and "personal equation" of other officials due to individual optimism or pessimism seems to me to render the application of a uniform percentage correction to these particular estimates quite inappropriate.

on, it would be necessary to find a suitable yield to replace the conventional percentage of "failed" crops. This could be done approximately by comparing the percentage of failure in a year of "normal" climatic conditions in which the yield could be determined from source (c).

As to (c), this is undoubtedly the most reliable though not the longest series of yields. It is open to the objection that it represents a specialized agricultural environment, but at the same time, it is a very valuable guide to yields all over India.

As to the Season and Crop Report yields, there is more than one reason for doubting their accuracy except in a rough qualitative sense. Provincial yields are based on the guess-work, intelligent or otherwise, of various officials. Even expert agricultural officers may make *average* errors of as much as 25 per cent. or more in estimating the yield of crops on fields with the yield of which in previous years and with the detailed agricultural treatment of which they are familiar.[1]

J. A. Venn has recently indicated the official British methods of crop estimating[2]. Two of the reasons he gives for doubting the estimates of yields in Britain have a certain relevance as against Indian yield statistics. Thus he gives the following interesting table of the variation of yield of wheat in different countries for the ten years 1910-19.

Country	Mean deviation of wheat yield per unit of area
	Per cent.
Denmark	13·4
Germany	10·4
Holland	7·3
New Zealand	13·0
Sweden	10·6
Switzerland	11·8
United Kingdom	4·5
England	4·7
Scotland	4·5
Ireland	2·4

The mean deviation of the yield of Indian wheat for the same years (1910-1919) is only 4·9 per cent.,[3] or little more than the 4·5 per cent. of variation which Venn considers, with some reason, to be improbably small.

Likewise Venn's opinion that the English yield statistics "refuse recognition to the plant-breeder" might be held also of Punjab wheat statistics, the yield per

[1] *Rept. of the Operations of the Dept. Agri., Punjab*, 1919-20, Pt. I, pp. 31-33.

[2] Venn, J. A. An enquiry into British methods of crop estimating. *Eco. Jour.*, Sept. 1926.

[3] The figure of the "co-efficient of variation" previously given (*viz.*, 7·8 per cent.) is for a slightly longer period and is, of course, calculated differently from the "mean deviation". In a "normal" distribution the "mean deviation" is about ⅘ths of the "standard deviation."

acre of the 12 years 1911-1922 being, according to the official figures, exactly the same as of the preceding 12 years, 1899-1910.[1]

Briefly, then, the only yield statistics in India which are really accurate are those of the agricultural experiment stations. The data provided by these stations must be carefully examined by the worker in Agricultural Meteorology. But he must be prepared for much disappointment, as only a very few experiments have been systematically conducted over a series of years to elucidate the effects on yield of such relatively simple causes as irrigation and subsoil moisture.

Besides these the revenue records showing the "failed" area of crops have a good deal of significance and ought to be analysed in terms of meteorological factors. If this work is carried on from the stage reached in 1916[2], the translation of figures of percentage failure (Kharaba) into bushels or pounds per acre, though not an easy task, is likely to furnish a useful basis for forecasting.

SUMMARY.

To sum up, the variation in the outturn of crops in India is a dual problem of the variation of the areas sown to each class of crop and the yield of these crops per unit of area. These problems are to be thought of as the fundamental ones of—

(1) Quantitative Agrononics, of which Agronomic Meteorology is one of the most important branches, and

(2) Agricultural Meteorology.

Agricultural Meteorology has recently aroused world-wide attention, and India's climate with its well-marked features should make Indian crop-experimental evidence suitable for interpretation.

Fairly favourable as conditions in India are for the study of Agricultural Meteorology, yet for the solution of the problems of Agronomic Meteorology the data provided by Northern India are unsurpassed in the whole world for the space and time they cover, their accuracy and their continuity. Add to which the statistics of area of crops, of numbers of ploughs, of cattle, of mortgaged areas, of numbers of wells, with the classification of forms of irrigation, which are given in detail for each economic molecule, the Indian village community. Not only can the fluctuations of areas be studied in old existing villages, but the increases in area associated with the formation of new villages can be traced with great detail in the revenue records of the colony tracts.

[1] D. S. Dubey's calculation (A study of the Indian food problem. *Agri. Jour. India*, XVI, Pts. III and IV) of an annual deficit of 7·8 million tons in food production below estimated requirements suggests that the production estimates may be too low.

[2] Jacob, S. M. Correlation of rainfall and the succeeding crops with special reference to the Punjab. *Mem. Ind. Met. Dept.*, XXI, Pt. XIV, 1016.

The statistician, who does not become the slave either of his statistical material or of his mathematical methods, can, I feel sure, obtain in Indian statistics a clue to the variation of crop areas with variations of climate and weather; in other words, he can throw light on the fundamental problem of Agronomic Meteorology.

He will also, though he is not exceptionally well served on the side of yield statistics, have an opportunity of helping to solve some of the world problems of Agricultural Meteorology.

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, DR. J. T EDWARDS; *Secretary for Publications*, MR. S. K. SEN).]

X. BURSATI, SUMMER SORES OR CUTANEOUS HABRONEMIASIS: A SHORT REVIEW OF THE LITERATURE.

BY

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Bursati is the name used in India to designate a disease condition in equines which is characterized by the presence of an ulcer or ulcers implicating the skin and the subcutaneous tissues of the body. The progress of the disease is marked by certain peculiarities, the most distinctive of which is the formation of certain peculiar bodies, known as *kunkurs*, which lie embedded in the lesions and remain for some time as irritants. According to Lingard, the disease usually makes its appearance towards the close of the hot season and continues to prevail during the Rains. It is possible, however, that the various forms of granular dermatitis in equines, known collectively under the name of *bursati*, do not originate in the same manner, and the difficulty of discriminating between these forms merely on clinical grounds has been emphasized by Descazeaux (1915) who observes that our clinical knowledge is not yet so precise that one can differentiate, by means of simple external examinations, between verminous dermatitis and dermatitis due to fungus.

The question of the ætiology of *bursati* has been the subject of considerable speculation from time to time. The disease has sometimes been identified with various forms of equine dermatitis occurring in Europe and America, such as "leeches" (Lyford, 1886; Bitting, 1894; Fish, 1897), "summer sores" (Fleming, 1892; Lingard, 1905) and "swamp cancer" (Gilruth, 1912).

Leaving aside the primitive efforts to attribute the disease to such vague and ill-defined causes as poverty (Kerr, 1829), debility (Western, 1852), and the temperature of the atmosphere (Tombs, 1831), two hypotheses have been advanced in regard to the ætiology of *bursati*, namely, (1) that the disease is of verminous origin, (2) that the causal agent is of the nature of a fungus.

As early as 1842, Jackson diagnosed the disease as being due to a fungus, but F. Smith (1884) would appear to have been the first who actually demonstrated a fungus in the affected tissues, although he failed to obtain any result by the inoculation of this material.

In 1885, Steel obtained cultures of the fungus and concluded: " *Bursati* takes its place among parasitic disorders of fungal origin. Closely resembling certain vegetable parasitic diseases of the skin, it somewhat approaches the cancer in invading internal organs as well as the surface of the body ".

In 1914, Holmes published a memoir in which he referred to the association of the disease with a fungus of the genus *Sporotricum*, but although he obtained cultures of the material, he failed to cause the disease by experimental inoculation.

In 1905, Lingard published a series of observations which, so far as their bearing upon the question of the ætiology of *bursati* is concerned, may be summed up as follows :—If the tissues of a well-marked *bursati* sore of recent formation be subjected to examination, it will be found that instead of hard nodules undergoing a caseous change, soft masses are encountered, which are enveloped in dark-red coloured coverings, which, on microscopical examination, prove to be only red corpuscles. On removal of this outer layer an inner colourless layer is encountered, which is composed of white corpuscles undergoing proliferation, and within this again, a felted aggregation of dead nematode embryos is encountered. The identity of this " felted aggregation " has, however, since been questioned by more than one worker, particularly by Gaiger (1916), who has even adduced evidence in support of his contention that the so-called " felted aggregation " of Lingard represented, in reality, merely muscle fibres.

Investigations conducted by Place (1908) in India pointed to the causal connection of *bursati* with filarial worms and fixed the blame for the disease on two species of flies (*Musca domestica* and *Stomoxys calcitrans*). In support of his contention Place referred to the " absence of *bursati* from fly-free areas." Place's views, however, were subjected to criticism by Gaiger (1915), who did not " believe that any part of India is free from the house-fly and the almost as familiar *Stomoxys*," whilst, in regard to the occurrence of the filarial embryos in the lesions, he regarded them merely as a contamination, and he gave it as his " firm opinion that *bursati* has no connection either with embryonic or adult filariæ or with flies." Nevertheless, there would appear to be a large amount of circumstantial evidence to indicate that *bursati* may, in reality, be a form of habronemic granuloma, such evidence being particularly furnished by the following facts : —(1) The abundance in India of *Musca domestica* and *Stomoxys calcitrans*, the vectors of the parasites ; (2) the widespread distribution of the worms themselves in the stomach of equines ; and (3) the marked " eosinophile infiltration " usually noticeable in *bursati* lesions (indicative of verminous infection). It would be of interest in this connection to present a brief résumé of the literature relating to " summer sores " and " esponja "—the two forms of equine dermatitis definitely known to be casued by *Habronema*.

The more important symptoms of "summer sores" are thus summarized by Nielsen (1924):—The limbs are most frequently affected. Wounds such as are due to calk abrasions, and in fact any traumatism accompanied by solution of the skin, are the primary causes. The wound, instead of healing rapidly, begins to suppurate. After the lapse of a few days a soft grayish red granulation tissue appears. A marked inflammatory reaction is noted in the adjacent tissue immediately surrounding the wound, with swelling and tenderness. A characteristic symptom is an intense itching of the part. This latter phenomenon is especially evident in extreme hot weather when the patient is confined in a warm humid stable. The large quantity of exudate present in the first stages indicates that the lesion is essentially that of an acute inflammation. The clinical picture changes later. The exudate abates, the itching ceases and the granulations become firm and smooth. On closer examination one observes that there are present small, yellow nodules situated in the depths of the wound and on the surface. There is now a tendency towards covering with epithelium, but the healing is extremely slow in progress.

A study of the available literature shows that Bouley (1850) was the first to describe "summer sores" in France. He observed that the lesions appeared only during the hottest part of the year and disappeared at the end of the summer, and he therefore believed that the heat of the summer was the primary cause of the disease.

In 1860, Ercolani signalized the presence of a nematode in the subcutaneous connective tissue at the base of freshly formed umbilicated crusts. He described and figured it under the name of *Trichina uncinata*, while remarking that it presented considerable resemblance to the embryo of *Habronema*.

In 1868, Rivolta described a notably large larva found in the granulations of the lesions. He gave to this larva the name of *Dermatofilaria irritans* which, later, was renamed by Railliet *Filaria irritans*.

It was, however, not until the findings of Laulanie (1884) and particularly those of Fayet and Moreau (1908) that the parasites received recognition in France as the probable cause of granular dermatitis in equines, and in 1911, Railliet and Henry, after a careful examination of material obtained from "summer sores" at Senegal, definitely incriminated these worms as the causative agents of the disease.

In 1915, Van Saceghem gave an account of observations made by him, in Zambi, on numerous cases of granular dermatitis which he considered to be due to a nematode larva, called by him *Filaria irritans*.

Although the fact of the causal connection of these forms of granular dermatitis with worms was thus generally recognized, the exact identity of the worms, however, was not disclosed until Descazeaux published figures of the various larval forms isolated from the granulations of what is known in Brazil under the name of "esponja." In 1915, Railliet and Henry elaborated the observations of Descaze-

aux, and in doing so had no difficulty in proving that the larval forms isolated by Descazeaux represented, in reality, the young stages of *Habronema*.

It has since been found out that three species of *Habronema* are concerned in setting up the disease condition known as "summer sores", namely, *H. muscæ*, *H. microstoma* and *H. megastoma*. The normal habitat of these three species is the stomach of equines, *H. muscæ* and *H. microstoma* occurring free and *H. megastoma* in adonematous-like growths which may attain the size of an orange. The localizations known as "summer sores" do not represent the logical development of a normal course of events, but are brought about as a result of what may be called "erratic" habits on the part of the *Habronema* larvæ. In the lesions the larvæ are able to undergo only a very restricted development, and after wriggling about and causing an inflammatory reaction for some time, they die and become calcified, being subsequently found in well-defined necrotic or caseous areas, buried within the affected tissue.

Following upon the discovery of the causal connection of "summer sores" with *Habronema* worms, intensive efforts were made in several countries to ascertain the exact manner in which the worms found their way into the lesions. Descazeaux shared with Rivolta the view that the worms penetrated the horse's skin from without, and in support of his view he cited the fact that "esponjas" were localized by preference to the lower parts of the limbs which were particularly exposed to dirt. On the other hand, Laulanie observed the arterioles of the skin in a process of obliteration, and thus thought that the penetration took place from inside outwards. Similarly, Lingard, in India, pointed out in the case of *bursati* which he attributed to filarial embryos circulating in the blood, that the characteristic granulations of these lesions made their appearance before the formation of an ulcer.

As far back as 1861, Carter had found a larval nematode in the proboscis, head, and abdomen of the domestic fly. Ransom (1913) showed that this larva belonged to one of the *Habronema* worms (*H. muscæ*) which live in the stomach of the horse and that the embryos evacuated in the fæces penetrate into the larvæ of flies (which normally breed in horse manure) and undergo development in the larvæ as well as in the pupæ and fully-formed flies and arrive at the adult stage in the stomach of the horse after the flies have been ingested by this animal. Whilst the normal habitat of the worms outside the definitive ho t was thus determined, the actual extent to which the flies were responsible for the introduction of these worms into the lesions was still the subject of speculation. Railliet (1914), while believing that the flies acted as intermediate hosts of the parasites, was also inclined to the view that the embryos after being ejected with the fæces, penetrated the skin of the animal in the same way as the hookworm, there setting up an inflammatory reaction eventually leading to the formation of a sore, in which abnormal medium the parasites underwent an evolution analogous to that which they normally accomplished in the body of the intermediate host.

In a series of papers published in 1917-18, Van Saceghem, however, brought forward a large amount of circumstantial as well as experimental evidence in support of the hypothesis that flies were the predisposing factors in the spread of the disease. The facts adduced by him were as follows :—(1) The disease was rare amongst equines which were allowed to graze about at liberty during the day, although they passed the night in contact with *Habronema*-infested dung (according to the author, house-flies and *Stomoxys* are numerous in stables and are rare in jungles) ; (2) the disease never occurred in the hind quarters but was always localized in the fore quarters on the legs and at the inner canthus of the eye, *i.e.*, in regions which were beyond the reach of the tail of the animal, and this proved that the flies were beaten away from the hind quarters ; (3) nematodes taken from a fly and placed on the moistened skin of a guinea-pig showed no tendency to penetrate the skin, but when the larvæ were placed on an abrasion, they quickly buried themselves in the tissues ; (4) horses with abraded skin and confined with *Habronema*-infested flies developed "summer sores" only when such abrasions were left unprotected, but the wounds healed in a normal manner when they were kept bandaged and thus protected from the invasion of flies ; (5) similarly, eyes not protected from contact with *Habronema*-infested flies developed "habronemic conjunctivitis," but when the eyes were kept covered with a net, they did not develop the disease, although the animal was kept in constant contact with infested flies ; (6) there was massive infection at a single point, which indicated that certain sites, such as an abrasion, showed a predisposition to the disease.

During recent years much further light has been thrown on the ætiology of summer sores. In a notable contribution on the subject, Roubaud and Descazeaux (1921) have discussed the question of the mechanism by which the parasites are released from the proboscis of the fly. These authors explain the close analogy between the development of *H. megastoma* in the house-fly and that of certain filarial worms in the mosquito, and they have brought forward experimental evidence to prove that the escape of the parasites from the proboscis of the fly is a spontaneous act of liberation depending upon two essential requisites, namely, warmth and moisture. They have also shown that mere moisture has no effect on the larvæ inasmuch as they have found it impossible to get worms from infected flies by feeding them on such media as sugar, blood and pus. Under natural conditions, infestation with *H. megastoma* would therefore appear to occur by flies alighting on abrasions (cutaneous habronemiasis), or on nostrils (pulmonary habronemiasis), or on the lips (gastric habronemiasis), although, according to these authors, in the last-named condition infestation may also occur, exceptionally, through the ingestion of parasitized flies, as is indicated by the fact that when a dead infected fly is warmed in water, the larvæ emerge not only from the proboscis but also from the cuticle of the abdomen. A spontaneous liberation of the parasites is also indicated in the case of *H. microstoma* which has for its intermediate host the biting insect *Stomoxys calcitrans*. As early as 1918, Hill observed that the proboscides of *S.*

calcitrans were frequently clogged with the parasites to such an extent that the flies were almost incapable of piercing the skin. Roubaud and Descazeaux (1922) confirmed Hill's findings and also observed that under such conditions the flies—although normally vicious biters—were reduced to the habit of absorbing the moisture available on the surface of the lips, nostrils or wounds.

As to the treatment of "summer sores", Van Saceghem (1919) claims to have had good results by protecting the lesions from the attacks of flies by covering them with an adhesive plaster, with which may be incorporated a repellent for flies. The following formula is recommended by him: plaster of paris 100, alum 20, naphthaline 10, and quinine or any other bitter powder 10 parts; this should be repeatedly applied until the exudation ceases completely.

Recently, encouraging results are reported to have been obtained by certain veterinary authorities in India in the treatment of *bursati* by the internal administration of tartar emetic by intravenous injection. The method, however, does not appear to have been, as yet, sufficiently worked out to recommend it for general adoption.

PLATE XXXIII.

FIG. 1. In front of, and below, the rear end of that pole, is the place for the implement.

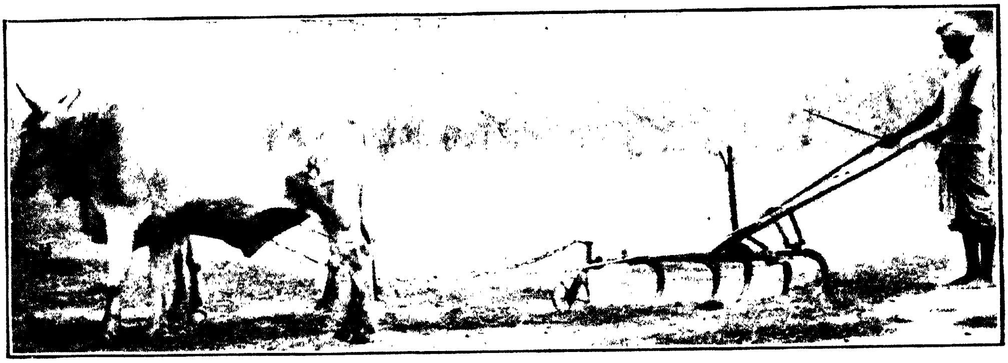

FIG. 2. A 5-tined horse hoe, used for the intercultivation of cane, as sold by the agents.

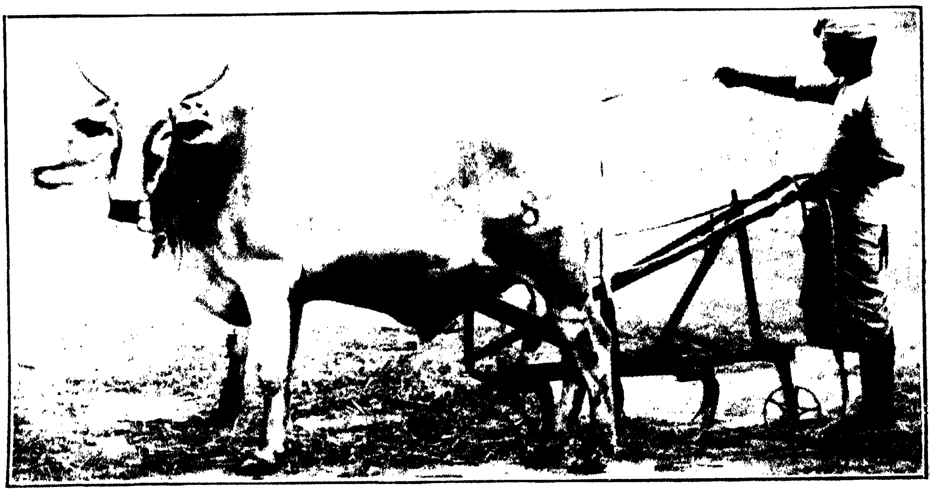

FIG. 3. The same adapted to bullock draught. The reduction in turning room required, and the greater control possible, are clear.

AGRICULTURAL IMPLEMENTS SUITABLE FOR THE USE OF THE INDIAN CULTIVATOR.

BY

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INTRODUCTORY.

EVERY newcomer to the agriculture of India is amazed at the primitive appliances with which the land is cultivated. He remembers the minimum equipment found necessary by the poorest of western farmers—the plough, cultivators and harrows, ridging plough, seed drills—and compares this with the ryot's outfit of hoe, country plough and beam; and his wonder grows. In time he realizes that with these few tools, the cultivation is only done at the cost of enormous labour by man and beast, and even then comparatively inefficiently; because many important operations of husbandry such as intercultivation and earthing up can only be done by the hoe. Later he judges that the low standard of cultivation is an important link in the chain of circumstances that keeps the ryot poor, and urges the adoption on a wide scale of such implements as are used in the West. At once he encounters the full force of the limitations and disabilities under which the Indian cultivator labours.

Apparently, the world over, certain essential tools are required for the efficient cultivation of land in areas of any size larger than a garden plot. These are—the plough to break the surface to a moderate depth, to bury manure and weeds and to loosen thoroughly sufficient soil to form a seed-bed; the cultivator or harrow, to work this broken soil and so reduce it to a reasonably fine tilth, and to kill small weeds before and after sowing; and the ridge plough, to open furrows for the sowing of crops like cane and potatoes, and to earth up, for cleaning and draining purposes, such crops as cane, cotton, maize. Yet the Indian cultivator struggles to perform these operations with a wooden plough; and where that fails him, *e.g.*, in deep cultivation and to kill weeds among crops, falls back on the hoe. Why? From the numbers of western implements sold in India to-day, and the obvious interest taken by cultivators in their use whenever they are met, it seems the will is there. But the ryot is prevented from acquiring these more efficient tools by (1) his poverty, (2) his bullocks, (3) the size of his fields, and (4) his lack of knowledge of mechanics.

Firstly, his intense poverty makes the purchase of such implements as are available, utterly impossible, however well they are worth the price asked. Undoubtedly

in this, as in many other improvements the ryot might well adopt, there is a definite, and very low, limit to the primary outlay he can face, however great the prospective return. We can probably assume that very few implements will sell at more than Rs. 10, while to reach the million Rs. 5 should be the price aimed at. But what a market exists : how the appetite would feed upon itself, as the first few really suitable ploughs or cultivators appeared in the districts, and the first owners promptly dispensed with half their bullocks, and told their sons and brothers that they need not return from the mill or the mine for the monsoon or *rabi* sowings, as the new tool got through the work at twice the pace of the old one. The rest of the world has been in the iron age for centuries, while to-day iron and steel are cheap in India, and the industry is being fostered at great cost. Standardization has captured most of the world, and was evolved for just this work. Ample labour, cheap and sufficiently skilled for easy training to the simple processes involved, could well be withdrawn from competition in, to service for, agriculture. In short, what an opportunity for a Ford, who would design the tools that are wanted, and sell them at the price the millions could pay, so organizing their production as to leave himself a substantial margin.

The next two disabilities may well be considered together, namely, that cattle are the Indian draught animals, and that fields are small. Practically all improved implements sold for cultivation in India are primarily designed for use with horses or mules, the few that are advertised as for bullock draft being deficient in some important respect. Generally if one light horse or a mule can draw the implement it is considered suitable for use with Indian bullocks. The facts are neglected entirely, that the time-honoured method of driving bullocks is to push them along with a short sharp stick, and to encourage them at intervals by twisting their tails ; and that the speed of the cattle, and their amenity to control, decrease progressively as their distance from their driver increases. When the latter is steering a Punjab plough or the common type of 5-tined cultivator, such as the "galian" common on Bihar plantations, the bullocks, straining at their draught chain, are four or five yards ahead. Only his voice can reach them ; and that, efficient in volume and range as it notoriously is, after an hour's vigorous use becomes so attenuated as barely to suffice to keep the "slow patient" oxen awake. Again, the plots on this side of India seem to vary from the size of the floor space of a room to that of a house. Our improved implements are often barely half across a field, when the bullocks are at the boundary and trampling the neighbouring crop. Even where the position is not quite so farcical, width of headlands and turning room at the side of the field, are vitally important ; and it is absolutely essential to reduce the over-all-length of any implement to the minimum.

This question of over-all-length is so fundamental and, except in the case of the plough, so simply dealt with, that it can conveniently be elaborated more fully at this stage. Implements to be drawn by cattle, and used in small plots, and this includes all implements for use in India and the East generally, must be so designed

FIG. 1. A "galian" of a type common on Bihar plantations as usually sold and worked.

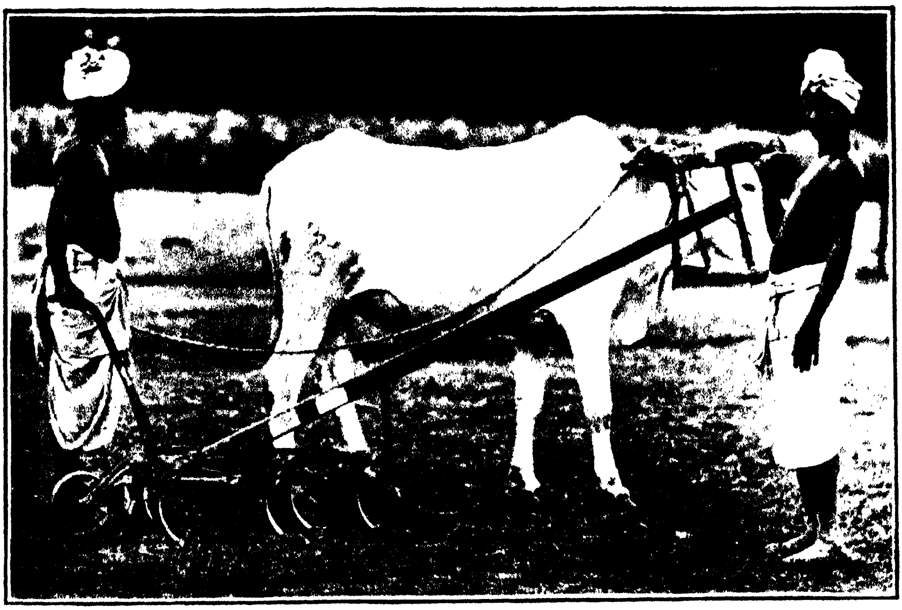

FIG. 2. The same converted to bullock draught. The reduction in turning room and increased control are obvious.

FIG. 1. When the cattle are yoked, the machine should be between their hind quarters.

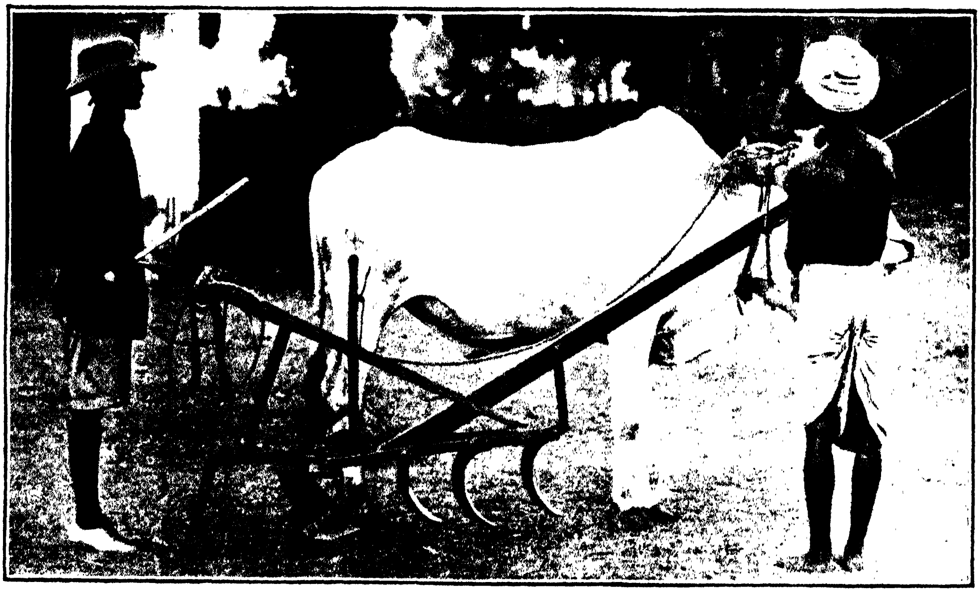

FIG. 2. A five-tined cultivator with the wheel dropped and the hitch shortened sufficiently to raise the tines clear of the ground, for transport along the road.

that the driver can reach his cattle with a short stick; and the implement must be as far as possible forward between the bullocks, so that when they reach the boundary of the field the implement is also there, or nearly so.

Call up a pair of ordinary cultivators—bullocks in their yoke—and make a man stand just so far behind them as to be able to reach them comfortably with a two feet stick. From there he can drive them comparatively efficiently. Now lay a pole, the fore end resting on the yoke, and the rear end on the ground just so far in front of the man's feet that he does not kick it as he walks. In front of, and below, the rear end of that pole, and fastened to it, at two or three points, is the place for the implement (Pl. XXXIII, fig. 1).

In the ordinary country plough yoke, the space between the cattle, measured from the near hind of the one to the off hind of the other, is always over 2 feet, ample width for any implement likely to be of general use to the cultivator.

At the present day there are in use in India and in stock with the agents thousands of rigid five-tined cultivators and ridge ploughs, all of which would be increased 50 to 100 per cent. in efficiency if they were adapted to pole draft; and practically all of them, at little cost, can be so altered. All have a central beam and, in the case of the cultivators, on that is hinged the two side beams; and behind that hinge are the handle fittings and those of the expanding apparatus (Pl. XXXIII, figs. 2 & 3; Pl. XXXIV).

Shift the wheel from the front to the rear; and move, as far to the rear as possible, the expansion fittings. Immediately in front of the front central tine, bend up the front part of the central beam, if possible 12″ to 14″, vertically into the air. If the available front piece is too short, bolt on extra piece on to it, after it is bent upwards. Then fasten your pole by bolting the rear end to the central beam, as close as possible to, and just in front of, the expansion fitting; carry it forward in a vertical plane at a slope of 2 in 4 or 5; and where it crosses the vertical front part of the beam bolt the two together. Fit the handles as conveniently as possible after the pole is fixed, taking care not to let them project behind the machine any further than necessary. When the cattle are yoked the machine will be between their hind quarters (Pl. XXXV, fig. 1).

The working depth can be adjusted by fixing the wheel at the desired distance above the bottom of the tines, and then moving the yoke forwards or backwards along the pole, till all the tines run level; which is very similar to the method by which the cultivator adjusts the depth of his country plough. To move the machine along a road, drop the wheel as low as possible, and bring the yoke back along the pole till the tines are lifted clear of the ground (Pl. XXXV, fig. 2).

It is not maintained that these alterations alone will sell the machines to the ryot. Their price is far too high, and they are too complex to be saleable to more than a very small fraction of the people requiring them. But fitted with a pole, they will appeal far more powerfully to the few people who do use them.

The fourth disability keeping apart the ryot and the improved implements is lack of mechanical knowledge on the part of the general body of cultivators. String and wedges seem to comprise their only means of joining things together. The simplest western implement bristles with bolts and nuts ; and, judging from the habits of the comparatively trained ploughmen met on Government farms, any widespread use of these implements would result in an enormous consumption of these useful articles. India would be accused of hoarding them, as now she does gold, whereas in truth she would be inadvertently ploughing them into her soil. But it is worth very serious consideration as to whether it is not possible to devise the implements so that they can be fastened together entirely by rivets, wedges and pins. If that can be done, it may be possible, by aiming at simplicity in other directions also, to shirk this disability for a generation or two ; by which time, the knowledge of bolts and nuts, spanners and lubrication, at present being disseminated from industrial schools, and into passengers of motor buses coming unscrewed by the wayside, will possibly permeate the villages.

On and off for nearly 14 years the writer has, in Africa, Central and North, and in India, struggled to compromise the requirements of the work to be done with the disabilities that have been described. In a further article he will discuss what, in the light of the experience gained, seems to be the minimum equipment with which the Indian ryot can cultivate his land at a level of efficiency more nearly approaching that of the present century. He will also describe types of implements, comprising that equipment, designed partly to meet, as far as possible, the limitations of the cultivator, and partly to suit the requirements of standardization and mass production, so essential for cheapness.

Meantime correspondence on the points raised will be heartily welcomed ; and if any firms, interested in the supply of agricultural implements to cultivators, judge that on the hints so far given they can so adapt their business as to supply more nearly what the ryot wants, we shall be pleased to give them all information and other help which may be in our power.

APHIDS AND LADY-BIRD BEETLES.*

BY

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FIGHTING insect pests of crops by means of their natural enemies is a very interesting line of work, to which constantly increasing attention is being paid by entomologists in other countries, especially in America. In India this method of controlling insect pests has special advantages because, for evident reasons, the use of poisonous sprays cannot be safely recommended to the uneducated ryot. But so far no extensive trials as to the possibilities of success or otherwise, of this method of treatment, appear to have been given in this country. The only attempt along this line in the past, of which the writer is aware, was the introduction into the Punjab of *Microbracon lefroyi*, Ddgn. and Gough, against the Spotted Boll-worms of cotton (*Earias insulana*, Boisd., and *E. fabia*, Stoll.) in 1906 and 1911. And more recently, attempts have been made in Southern India to control the spread of *Nephantis serinopa*, Meyr. by means of its insect parasites. The value of *Microbracon lefroyi* as an adequate check on *Earias* spp. has been questioned, but parasites of *Nephantis* are reported as very satisfactory in certain localities.

The value of Lady-bird Beetles, as checks on Aphids, has been put to test on a small scale, and the results achieved have been satisfactory. On two occasions the experimental wheat plots of the Imperial Agricultural Bacteriologist, Pusa, were infested with Aphids, and on both the occasions the pest was effectively controlled by liberating into these plots lady-bird beetles collected from other fields. In this connection it will not be out of place to mention that there exists a very useful practice in the Punjab of sowing *toria* (*Brassica campestris*) at the time of wheat sowing. *Toria* ripens much earlier than wheat and is invariably attacked by Aphids. Later on when wheat comes into ear this also is attacked by Aphids. But by this time lady-bird beetles are found plentifully in *toria* fields. At about this time *toria* is harvested and the lady-bird beetles are compelled to seek " fresh fields and pastures new " for the propagation of their species. They migrate to the wheat fields where they find plenty of food for themselves and for their progeny and multiply. For this reason the wheat crop in the Punjab almost invariably escapes with only a very slight damage by Aphids, which is so insignificant that it is not considered worth recording in the official weekly " Crop and Weather Reports " of the Province

* **Paper read at the Indian Science Congress, Lahore, January 1927.**

Last year, on 1st February, 1926, the Imperial Economic Botanist, Pusa, reported that his experimental plot of lentil (*Ervum lens*) was very badly affected by Aphids, and he requested that something to save the crop might be done. This experimental plot covering nearly 1,200 square feet contained a little over 1,500 plants in it, and all of these plants, without any exception, were in flower and had plenty of Aphids on them. Some of the plants were bagged to avoid cross-fertilization, and these were attacked very severely indeed. The crop was sown on 21st November 1925, and the Aphids were noticed in the first week of January 1926, and became very abundant towards the close of the month. At the time of his examination, the writer observed a couple of eggmasses of a certain species of lady-bird beetle on two wooden posts driven in the field, carrying labels—a very unlikely place for the eggs. But this revealed the presence of the natur l enemy of the Aphid somewhere in the Botanical Area, and it was sure to appear on the scene sooner or later. It has been observed on several occasions that these natural enemies of insect-pests do appear in the affected fields, but their appearance is always too late to be of any material assistance. It is, therefore, of very great advantage in control work to help their early introduction and consequent multiplication in the affected fields. On a search being made, lady-bird beetles were discovered in very large numbers in a lucerne field separated from the lentil plot by a distance of about 500 yards. Half a dozen boys were put in to collect the beetles from the former and to liberate them into the latter plot. They liberated on an average a thousand beetles a day for three days from the 2nd to 4th February 1926. There were eighty-eight bagged plants and six beetles were introduced in each of the bags. The plot was re-examined on 15th February 1926, and the plants were found to be completely cleared of the pest.

Similar successful results could surely have been obtained by spraying the plants, but spraying would have vitiated the experiment as the crop was in flower and the flowers could not have escaped injury, however carefully the spray were to be applied.

The cost of treatment in this particular instance was practically a negligible factor as the boy-coolies, working in the Botanical Area, were simply diverted from their other duties on to this work for a couple of hours daily for three days. The boys are usually paid at Pusa at the rate of three annas per day of eight hours.

The above note is intended to stimulate interest in this method of fighting insect-pests of crops, so that workers may test the utility of it, when similar opportunities arise.

BREEDING IMPROVED SUGARCANES FOR THE PUNJAB.*

BY

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Government Sugarcane Expert, Coimbatore.

I. INTRODUCTION.

Now that two of the Coimbatore seedling canes are spreading into cultivation in this province, I have thought, it would not be out of place to interest this audience in the salient facts connected with the breeding of improved sugarcanes for the Punjab. In the present state of our knowledge, the breeding of improved canes for North India, including the Punjab, has to be carried on in the south in tropical India ; as such, a short description of the main features of sugarcane breeding is not likely to be too familiar to a North Indian audience. Cane breeding differs in certain important respects from the breeding of most other agricultural crops ; and this difference is not always fully realized even by those whose life work is on crops. This is my third reason for presenting this paper here.

II. THE SALIENT FEATURES IN SUGARCANE BREEDING.

As you all know, in ordinary cultivation, the sugarcane is propagated in the vegetative manner, *i.e.*, from cuttings or *sets*, as they are popularly called. Thus grown, the resultant plants largely resemble the planted cuttings in most characters. There is, however, one somewhat common exception to this, *viz.*, that of vegetative bud sports. In this case a sugarcane clump throws out a few canes - sometimes only one or two -- which are different from the rest of the canes in the clump in one or more characters. It is not unusual, for instance, to see striped canes throwing out a few unicoloured ones, the colour of the sport cane often being one of the component colours in the striping of the original parent. Attempts are being made in certain countries to try and utilize this character of the sugarcane for evolving improved strains.

Many sugarcane varieties frequently flower in the tropics ; but, for long, it was not known that they produced fertile seeds. This discovery was made in the eighties of the last century and, since that time, attempts are being made in most cane countries to raise new seedling varieties from seed with the definite object of securing improvements on the parent in one or more characters. One of the earliest benefits

* Paper read at the Indian Science Congress, Lahore, January 1927.

derived from sugarcane breeding has been the production of varieties resistant to disease ; and indications are not wanting that it would be of similar use in the future also. In the year 1912, the Government of India initiated breeding work in the interests of the Indian sugar industry by starting an Imperial Sugarcane Breeding Station at Coimbatore in South India. The station was located at Coimbatore, because it was found that the canes freely set seed in that locality.

When grown from seed, the plants do not resemble one another or the parents even when precautions are taken against foreign pollination. On account of this, the cane breeder secures, even in the first generation, practically as many new varieties as the number of seeds he has sown. This places the breeding of canes in a class distinct from that of most other crops.

The further propagation of the newly bred variety again differs, in a very important respect, from that of most other crops. When once a superior cane is obtained, it is subsequently multiplied for cultivation by the vegetative method from cuttings. This method has one advantage, *viz.*, that it preserves the original characters of the seedlings for fairly long periods. It would be absolutely futile to multiply the improved cane from seed, because any improvements obtained will be lost in the limitless variation of the second generation from seed.

Sugarcane breeding suffers from one very serious handicap as compared with that of most other crops. As you are doubtless aware, definite laws have been discovered in the matter of the inheritance of characters in most crops, and, in many cases, the inheritance has been found to be so orderly as to be expressed in mathematical formulæ. This is non-existent in the cane ; and, though certain definite indications have been obtained, it would, I fear, be very long before much accuracy is attained in this matter.

It is thus seen that, whereas (*i*) the early production of the improved types, and (*ii*) the absence of any need to fix the characters in the subsequent generations, are two distinct advantages in favour of cane breeding, the absence of well ascertained laws in the matter of inheritance introduces a large amount of chance in the success of the cane breeder's work. In the present state of our knowledge, the quickest means of achieving success in cane breeding would appear to lie in the raising of as large a number of seedlings as possible and from a wide range of combinations.

III. Flowering of sugarcanes in the Punjab not a disaster.

Sugarcanes do not generally flower in the Punjab and most parts of North India. At present this is assumed to result from the climatic conditions of sub-tropical India and all that they imply. One of the introduced Coimbatore seedlings, Co. 205, has, however, shown a certain amount of flowering in the Punjab.

There is a belief in the country that the flowering of sugarcanes in the field spells ruin to the crop. It is true that the flowering of a shoot stops further vegetative growth of that shoot. Secondly, the flowering often induces the shooting of the

lateral buds. Sometimes also the flowering results in the formation of a light pith in the centre when the crop is left in the field for some considerable time after the flowering.

If cut fairly early after the flowering, however, there is evidence to show that the flowering is not very harmful to the crop. In Java cane crops frequently flower and, as you know, the Javanese sugar industry is one of the most flourishing in the world.

Secondly, any disadvantages from flowering are likely to be less pronounced in North India than in the tropics. For one thing, it is within my personal knowledge, that the sprouting of the lateral buds does not take place with the same rapidity as in the tropics. In this connection it has to be remembered that the flowering and the maturing time for canes in North India is during the winter months with low temperatures ; and this would greatly minimize any harmful effects from the flowering of canes.

But this is not all. There would appear to be a distinct advantage associated with the flowering of canes in tracts like those of North India, where the growing period of a cane is limited and early maturing canes consequently possess a distinct utility. It was recently reported from Porto Rico that flowering canes gave one per cent. more sucrose and two per cent. higher purity than the non-flowering canes, and that the percentage of reducing sugars is also appreciably less. The conclusion is, therefore, drawn that, while flowering is not desirable in late varieties no in fields reserved for late cutting, it is clearly an advantage with early canes.

I have dwelt at some length on this subject because one of the introduced Coimbatore seedlings flowers in this province and it is possible others also might flower. I am rather anxious to dispel from your minds any prejudice against the flowering of sugarcanes as such.

The flowering of Co. 205 in this province has resulted in anxious enquiries whether the flowering might not be an indication of reversion or degeneration. There is a much simpler reason for the flowering of this seedling in the Punjab. One of its parents—the male parent—is a wild Saccharum, *viz.*, *Saccharum spontaneum* ; and a tendency to flower has been found to be a distinct character of seedlings having the wild blood in one of the parents. As some of the wild Saccharums do flower in the Punjab, I believe, the parentage of the seedling sufficiently explains the flowering of this seedling in the Punjab.

IV. Selection of a Punjab seedling at Coimbatore.

It would naturally be asked how it is possible to judge at Coimbatore the suitability of a cane for the Punjab. This is done in two ways. One of the first things attempted at the station was the collection and acclimatization at Coimbatore of the leading local canes of the Punjab. These varieties are now available at Coimbatore as standards with which to compare any new productions for the Punjab. Secondly, the local canes of the Punjab are being studied as to their general charac-

ters of growth, both in the Punjab and at Coimbatore; and the resulting data have been found of great help in selecting the improved types for this province.

V. Role of the Punjab Agricultural Department in the breeding of an improved cane for the Punjab.

It must however be admitted that the selection at Coimbatore for a province like the Punjab, which is nearly 2,000 miles away from it, is bound to be largely tentative. This first selection at Coimbatore is made none too rigid, through fear of losing any that might ultimately prove useful, when grown in the Punjab. The more important and the final selection has to be made in the province itself and under the actual conditions of the province. I wish to say here and say it as emphatically as I can, that the breeding at Coimbatore is only half of the problem involved in improving the cane varieties in any province. The other—and I do not mind its being called the more important—half is the testing work as carried on in the provinces, at present by the Provincial Departments of Agriculture. When a Coimbatore seedling spreads into the district the provincial testing station deserves the major half of the credit in the good work.

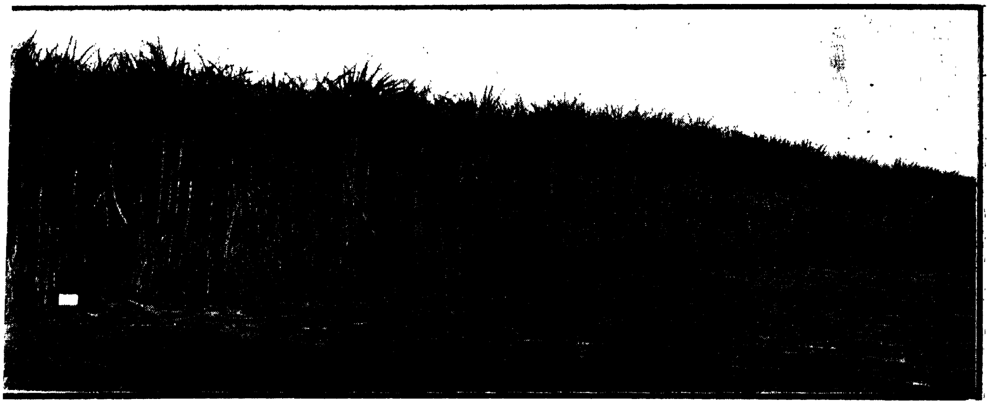
I here wish to express my great indebtedness to the farm at Gurdaspur and the various officers who have been in charge of that farm for very cordial and substantial help in my work at Gurdaspur. I have always been welcome to all data and records and treated as a brother officer at the station. I cannot be too thankful for the same.

The value of the co-operation of the provincial department of agriculture is evident from the fact that the seedlings have spread most where the local station has been most cordial. Like many other problems in agriculture the spread of improved seedlings into cultivation is largely team work; and I am always prepared to give my services to the testing station as one of the lesser members of the team.

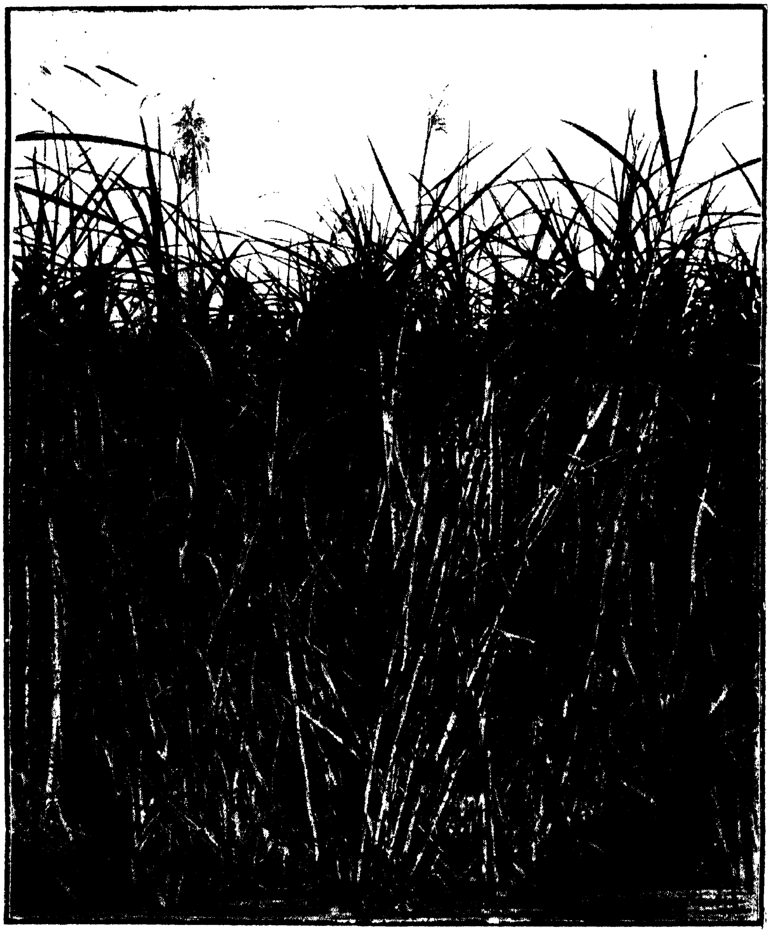
I refrain from giving any details as to the extent to which the Coimbatore seedlings have spread in this province because this is in the sphere of the local officers, to whom the entire credit is due.

VI. Punjab canes as parents.

With the idea of retaining the indigenous blood, an attempt was first made to raise seedlings from the indigenous canes of the Punjab. Two difficulties were experienced; some of the varieties would not flower in spite of various manipulations and others produced seedlings inferior to themselves. The breeding work had, therefore, to be carried on in a different manner; and, so far, crossing the tropical kinds with the indigenous canes of the Punjab or with the wild grass *Saccharum spontaneum*, has been the most fruitful in results. I hope it would not pain you when I say that the indigenous canes of the Punjab are some of the poorest in the world. I am glad, however, to be able to add that they are also some of the hardiest in the world.



Co. 205 grown without irrigation at the Government Farm, Gurdaspur (Punjab). It yields about 50 per cent. more *gur* (raw sugar) than the local canes.



Co. 205 grown in a ryot's field under swamp conditions. It yields in such conditions also about 50 per cent. more *gur* (raw sugar) than the local canes.

VII. Crossing the sugarcane with a wild grass.

The seedlings so far successful in this province have been those which have the wild blood in them either in the parents or in the grand parents. The climatic conditions in the Punjab are perhaps the most unfavourable in India for cane growth; and this, perhaps, explains the utility of a cross with the wild grass in producing a seedling useful for the Punjab.

The cross pollination with *Saccharum spontaneum* has led to certain interesting results and these are well exemplified in the seedling Co. 205 now spreading in this province. The grass is not only able to grow under conditions of limited water supply on account of its deep root system but thrives equally well under water-logged conditions. The seedling Co. 205 has shown both the above characteristics under cultivation in the Punjab (Plate XXXVI).

One important advantage with Co. 205 appears to be its comparative indifference to bad season, derived apparently from the grass parentage. This, I consider, an asset of considerable value, because the cultivator wants, more than anything else, a sure crop, in spite of the vicissitudes of the season which are only too common. This is particularly desirable in the case of large scale cultivation and when factories have to be fed with cane. The work at Coimbatore has shown distinct indications that the station would be able to materially help in the production of seedling canes, more resistant than the extant kinds to the vicissitudes of the season.

The pollinating parent has, however, introduced in the seedling certain drawbacks. One is that the juice is of comparatively poor quality and the second is that it is somewhat late in maturing under irrigated conditions. It is essentially a cane for unirrigated and water-logged lands and its best achievements would be on such areas.

VII. The need for an agricultural department under Central Government.

There is one point to which I would like to invite attention before closing this paper. The breeding of canes for India is essentially a work which, in the present state of knowledge, needs to be done by the Central Government. This is well illustrated by the work described in this paper.

If anywhere the local canes are in urgent need of improvement, it is in the Punjab ; in this province are found some of the poorest forms in the whole world. At the same time the local department is precluded from doing any breeding work, on account of the non-flowering of canes in the province. Even if the canes do flower, they do not produce fertile seed. Sugarcanes freely flower and set seed in the Madras Presidency ; but that province would not feel justified in initiating any elaborate work on sugarcanes, because the cane occupies but a subordinate place among the crops of the locality. The Madras Presidency enjoys a good climate for cane growth and, should that province ever start cane breeding, it will be on a type which would never grow in the Punjab. If the Central Government had not started the Coimbatore station, it is difficult to see how the Punjab could have secured the useful seedlings ; very likely the work would not have been undertaken.

THE EFFECT OF VARYING CONCENTRATIONS OF AMMONIA ON THE NITRIFYING POWER OF THE SOIL.*

BY

D. V. BAL,

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It is a matter of common knowledge that any organic nitrogenous substances added to the soil have to be first ammonified before the organic nitrogen can be converted into nitrates by the nitrifying organisms.

The production of ammonia from added organic matter may start almost immediately or may be somewhat delayed, and the intensity of the process may also vary according to the kind of soil. Thus, for instance, in some soils with good ammonifying and nitrifying power, the production of ammonia, and its subsequent conversion into nitrate, goes on simultaneously, and in such a case one rarely meets with any appreciable accumulation of ammonia in the soil. In some soils, however, where the nitrifying power is either too low or the ammonifying power is specially vigorous, accumulation of ammonia takes place to a large extent.

The writer has observed two such instances in the Central Provinces soils where accumulation of ammonia does take place to a considerable extent, and it is interesting to mention that one of the two soils is of a light porous character while the other is a heavy clay. It is known that the nitrifying organisms do not tolerate free ammonia and that in culture solutions they are sensitive even to ammonium salts. Hutchinson states that a high concentration of ammonia may be inhibitive to the production of nitrates in the soil.[1] The writer has not, however, come across any reference giving the maximum limit of ammonia accumulation which is tolerated by the nitrifying organisms in the soil. It was therefore thought of interest to obtain some information on this point, and to find out if there is any possibility of inhibition of soil nitrification due to accumulation of large quantities of ammonia under ordinary field conditions.

EXPERIMENTAL.

Black cotton soil which has been found to possess a very vigorous nitrifying power and whose analysis has been given in a previous paper was selected for this experiment.[2]

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* Paper read at the Indian Science Congress, Lahore, January 1927.

[1] Hutchinson, C. M. *Mem. Dept. Agri. India, Bact. Series,* I, p. 29 (1910-11).

[2] Plymen, F. J., and Bal, D. V. *Agri. Jour. India,* 1919, p. 416.

500 grm. lots of the soil were taken and the requisite amount of ammonia varying from 10 to 400 mg. of ammoniacal nitrogen per 100 grm. of soil was added, a standard solution of *puriss* ammonium hydroxide being employed for this purpose. The moisture content was then brought up to the optimum (½ saturation capacity) and the soils were incubated at a temperature of 30 to 33°C. Determinations of ammonia nitrite and nitrate nitrogen were carried out every two weeks, and the results obtained are given in the following table.

TABLE I.

Nitrogen as ammonia added per 100 grm. soil	Percentage added nitrogen found							
	After 2 weeks		After 4 weeks		After 6 weeks		After 8 weeks	
	As Ammonia	Nitrified*	As Ammonia	Nitrified*	As Ammonia	Nitrified*	As Ammonia	Nitrified*
Mg.								
10 . . .	10·40	80·10	..	83·00	..	102·00	..	102·00
20 . . .	16·00	70·05	..	76·75	..	96·00	..	96·00
30 . . .	1·70	74·00	..	90·00	..	98·00	..	98·00
60 . . .	22·00	34·00	1·80	94·00	1·80	94·00	..	92·00
80 . . .	26·00	5·40	9·00	70·00	1·40	94·50	..	94·50
100 . . .	49·53	3·90	20·46	55·10	4·30	88·20	..	92·20
200 . . .	43·10	*Nil*	44·15	*Nil*	44·70	*Nil*	..	6·40
250 . . .	49·20	*Nil*	40·50	*Nil*	38·30	*Nil*	..	0·60
300 . . .	43·10	*Nil*	38·40	*Nil*	36·20	*Nil*	..	0·20
350 . . .	37·00	*Nil*	31·50	*Nil*	32·60	*Nil*	..	*Nil*
400 . . .	35·20	*Nil*	31·00	*Nil*	30·10	*Nil*	..	*Nil*

* Nitrified nitrogen includes both nitrite and nitrate nitrogen.

An examination of the figures given above shows that a concentration of ammonia varying from 10 to 60 mg. of nitrogen per 100 grm. of soil does not materially affect the usual course of nitrification. When the concentration is raised to about 80 or 100 mg. of nitrogen per 100 grm. of soil, the intensity of the nitrification process is materially altered, and it takes about one month before any appreciable nitrate formation takes place. This shows that the nitrifying organisms are affected in the beginning but they recover from the adverse effects within a period of about a month

Concentrations of over 100 mg. of ammoniacal nitrogen per 100 grm. of soil are very injurious to the process of nitrification, and practically no trace of nitrate is found in the soil even after a period of 8 weeks.

Under ordinary conditions of manuring and cultivation there is no possibility of the occurrence in the soil of such a high concentration of ammonia as to adversely affect the process of nitrification. Even in soils heavily manured with sewage such a possibility does not seem to be at all likely. Taking a 3″ irrigation of sewage and the average nitrogen content at 15 parts per 100,000, the amount of nitrogen added per 100 grm. of soil is only about 4 mg.

SUMMARY.

1. Experiments on the effect of varying concentrations of ammonia on the nitrifying capacity of a soil are given.

2. From the results obtained it is seen that a concentration up to 60 mg. of ammoniacal nitrogen per 100 grm. of soil does not materially affect the process of nitrification, but concentrations of over 100 mg. of ammoniacal nitrogen are definitely injurious to the process of soil nitrification.

SELECTED ARTICLE

THE NATION AND SCIENCE.*

BY

THE HON'BLE HERBERT HOOVER.

I SHOULD like to discuss with you for a few moments certain relationships of pure and applied science research to public policies and above all the national necessity for enlarged activities in support of pure science research.

Huxley was perhaps not the first but at least he was the most forceful in his demand that preliminary to all understanding and development of thought was a definition of terms. Men in the scientific world will have no difficulty in making a distinction between the fields of pure and applied science. It is, however, not so clear in industry or in our governmental relations and sometimes even in our educational institutions.

At least for the practical purposes of this discussion, I think, we may make this definition that pure science research is the search for new fundamental natural law and substance, while applied science is clearly enough the application of these discoveries to practical use. Pure science is the raw material of applied science. And the two callings depart widely in their motivating impulses, their personnel, their character, their support and their economic setting. And these differences are the root of our problem.

As a nation we have not been remiss in our support of applied science. We have contributed our full measure of invention and improvement in the application of physics, in mechanics, in biology and chemistry, and we have made contributions to the world in applied economics and sociology.

Business and industry have realized the vivid values of the application of scientific discoveries. To further it in twelve years our individual industries have increased their research laboratories from less than 100 to over 500. They are bringing such values that they are increasing monthly. Our federal and state governments to-day support great laboratories, research departments and experimental stations, all devoted to applications of science to the many problems of industry and agriculture.

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*Address before the Society of Sigma XI and the American Association for the Advancement of Science, Philadelphia. Reprinted from *Science*, N. S., LXV, No. 1672.

They are one of the great elements in our gigantic strides in national efficiency. The results are magnificent. The new inventions, labour-saving devices, improvements of all sorts in machines and processes in developing agriculture and promoting health are steadily cheapening cost of production; increasing standards of living, stabilizing industrial output, enabling us to hold our own in foreign trade; and lengthening human life and decreasing suffering. But all these laboratories and experiment stations are devoted to the application of science, not to fundamental research. Yet the raw material for these laboratories comes alone from the ranks of our men of pure science whose efforts are supported almost wholly in our universities, colleges and a few scientific institutions.

We are spending in industry, in government, national and local, probably $200,000,000 a year in search for applications of scientific knowledge with perhaps 30,000 men engaged in the work.

I should like to emphasize this differentiation a little more to my non-scientific audience. Faraday in the pursuit of fundamental law discovered that energy could be transformed into electricity through induction. It remained for Edison, Thomson, Balle, Siemens and many score of others to bring forth the great line of inventions which applied this discovery from dynamo to electric light, the electric railway, the telegraph, telephone and a thousand other uses which have brought such blessings to all humanity. It was Hertz who made the fundamental discovery that electric waves may traverse the ether. It was Marconi and DeForest who transformed this discovery into the radio industry. It was Becquerel who discovered the radio activity of certain substances and Professor and Madame Curie who discovered and isolated radium. It was Dr. Kelly who applied these discoveries to the healing art and to industrial service. It was Perkins who discovered the colours in coal tar by-products. It was German industrial chemists who made the inventions which developed our modern dye industry. It was Pasteur who discovered that by the use of aniline dyes he could secure differentiation in colours of different cells, and this led to the discovery of bacilli and germs, and it was Koch and Ehrlich who developed from this fundamental discovery the treatment of disease by anti-toxins.

And so I could traverse at great length these examples of the boundaries and the relations of these fields of pure and applied science.

There is a wide difference in the mental approach of the men engaged in these two fields of scientific work. The men in pure science are exploring the frontiers of knowledge and they must necessarily do so without respect to reward or to its so-called practical benefits, whereas the men engaged in applied science research have long since demonstrated that it pays in immediate returns. It brings such direct rewards as to generate its own steam mostly through the Patent Office. There is seldom any direct financial profit in pure science research, although its ultimate results are the maintenance of our modern civilization and are the hopes for the future.

For all the support of pure science research we have depended upon three sources —that the rest of the world would bear this burden of fundamental discovery for us, the universities would carry it as a by-product of education, and that our men of great benevolence would occasionally endow a Smithsonian or a Carnegie Institution or a Rockefeller Institute. Yet the whole sum which we have available to support pure science research is less than $10,000,000 a year, with probably less than 4,000 men engaged in it, most of them dividing their time between it and teaching.

Some months ago our leading scientists in reviewing the organizations of pure science of the country were discouraged to find that their activities had been actually diminished during the last decade, whereas if these laboratories are to furnish the increasing vital stream of discovery to our nation, and our normal part to the world, they should have been greatly enlarged. Moreover, they discovered that the pressures of poverty in Europe were taking a worse toll of pure science abroad.

The causes in the United States are not far to seek. They arise from two directions : First, 80 per cent of the men devoted to pure science research with us are in our scores of universities and colleges. Our universities have doubled in the number of their students. Their pre-war endowments and income have been depreciated by the falling dollar. New resources have been given many of them, but not enough to handle their new burdens of teaching. All of this has led them to more and more curtailment and the suppression of expansion in pure science research in order that they might attend the immediate problem of education. Thus the four or five thousand men in the United States who had demonstrated their ability for research of this character are not applying themselves in this direction so much as they are applying themselves to the education of the youth. Teaching is a noble occupation, but other men can teach and few men have that quality of mind which can successfully explore the unknown in nature. Not only are our universities compelled to curtail the resources they should contribute in men and equipment for this patient groping for the sources of fundamental truth because of our educational pressures, but the sudden growth of industrial laboratories themselves and the larger salaries they offer have in themselves endangered pure science by drafting men from the universities. This is no complaint against our great industries and their fine vision of the application of science. It simply means we must strengthen the first line of industrial advancement—pure science research.

These men of pure science are the most precious assets of our country and their diversion to teaching and applied science reduces the productivity which they could and should give to the nation. It is no fault of their own but it is the fault of the nation that it does not give to them and to the institutions where they labour a sufficient support.

There is no price that the world could not afford to pay these men who have the originality of mind to carry scientific thought in steps or in strides. They wish no price. They need but opportunity to live and to work. No one can estimate the value to the world of an investigator like Faraday or Pasteur or Millikan. The

assets of our whole banking community to-day do not total the values which these men have added to the world's wealth.

Some scientific discoveries and inventions have in the past been the result of the genius struggling in poverty. But poverty does not clarify thought, nor furnish laboratory equipment. Discovery was easier when the continent was new. Discovery nowadays must be builded upon a vast background of scientific knowledge, of liberal equipment. It is stifled where there is lack of staff to do the routine and where valuable time must be devoted to tending the baby or peeling potatoes, or teaching your and my boys. The greatest discoveries of to-day and of the future will be the product of organized research free from the calamity of such distraction.

The day of the genius in the garret has passed, if it ever existed. The advance of science to-day is by the process of accretion. Like the growth of a plant, cell by cell, the adding of fact to fact some day brings forth a blossom of discovery, of illuminating hypothesis, or of great generalization. He who enunciates the hypothesis, makes the discovery or formulates the generalization, and thus brings forth the fine blossoms of thought is indeed a genius, but his product is the result of the toil of thousands of men before him. A host of men, great equipment, long patient scientific experiment to build up the structure of knowledge, not stone by stone but grain by grain, is now our only sure road of discovery and invention. We do have the genius in science ; he is the most precious of all our citizens. We can not invent him ; we can, however, give him a chance to serve.

And the more one observes the more clearly does he see that it is in the soil of pure science that are found the origins of all our modern industry and commerce. In fact our civilization and our large populations are wholly builded upon our scientific discoveries. It is the increased productivity of men which have come from these discoveries that has defeated the prophecies of Malthus. He held that increasing population would constantly lower the standard of living amongst men until the pressure of subsistence upon population would limit its number by starvation. But since his day we have seen the paradox of the growth of population far beyond anything of which he ever dreamed, coupled with a constantly increasing standard of living This result would be impossible but for the men of fundamental scientific research and discovery. In fact there is for the future but one contestment in the race with the principle of Malthus, and that is in pure science. If we would have our country increase in its standards of living and at the same time accommodate itself to an increasing population at the rate of more than 15 million each decade, we must maintain the output of our pure science laboratories.

The wealth of the country has multiplied far faster than the funds we have given for these purposes And the funds administered in the nation to-day for it are but a triviality compared to the vast resources that a single discovery places in our hands. We spend more on cosmetics than we do upon safeguarding this mainspring of our future progress.

But to return to my major theme—How are we to secure the much wider and more liberal support to pure science research? It appears to me that we must seek it in three directions—first, from the government, both national and state; second, from industry, and third, from an enlargement of private benevolence. We have long since accepted the obligation upon the state to provide universal and free education. We have advanced it further than any nation in the world. Yet the obvious function of education is to organize and transmit our stock of knowledge —it is not primarily concerned with the extension of the borders of knowledge except so far as the process is educational. It seems to me that we must accept the fact that the enlargement of our stock is no less an obligation of the state than its transmission As a nation we must have this enlargement of stock if we would march forward. And the point of application is more liberal appropriations to our national Bureaus for pure science research instead of the confinement as to-day of these undertakings for applied science work. And we must have the more liberal support of pure science research in our state universities and other publicity-supported institutions.

Our second source of support must come from business and industry. You are aware of the appeal in this particular from the National Academy of Sciences of a year ago—that they might be entrusted with a fund largely for the better support of proved men now engaged in such research in our universities and elsewhere. It is no appeal for charity or benevolence. It is an appeal to self-interest, to insurance of every business and industry of its own future. That appeal has been met generously by some of our largest industries; it is under consideration by others; it has been refused by one or two largely because they have not grasped the essential differences between the applied science investigations upon which they are themselves engaged and the pure science which must be the foundation of their own future inventions. A nation with an output of fifty billion annually in commodities which could not be produced but for the discoveries of pure science could well afford, it would seem, to put back a hundredth of one per cent. as an assurance of further progress.

Nor is the interest of a particular industry confined to the science research which appears on its face to be directly in the line of that industry. Practically all industry and all business gains by scientific discovery in any direction. The discoveries which led to the invention of the internal combustion engine and thus to the automobile have benefited every industry and every business in the United States. Business and industry have an interest in the common pool of scientific research irrespective of its particular field. Those fundamental discoveries of the germ basis of disease, with the load of mortality they have lifted from the race, have lowered the rates of insurance and thus contributed directly to business.

From benevolence we have had the generous support of some individuals to our universities and scientific institutions, but this benevolence has come from dis-hearteningly meagre numbers, as witness the discouraging results of recent appeals

from the Smithsonian—the father of American science—and failure of appeals from some of our universities. In a nation of such high appreciation of the value of knowledge, and of such superabundance of private wealth, we can surely hope for that wider understanding which is the basis of constructive action.

And there is something beyond monetary returns in all this. The progress of civilization, as all clear-thinking historians recognize, depends in large degree upon " the increase and diffusion of knowledge among men." Our nation must recognize that its future is not merely a question of applying present day science to the development of our industries, or to reducing the cost of living, or to eradicating disease and multiplying our harvests, or even to increasing the general diffusion of knowledge. We must add to knowledge, both for the intellectual and spiritual satisfaction that comes from widening the range of human understanding and for the direct practical utilization of these fundamental discoveries. If we would command the advance of our material and, to a considerable degree, of our spiritual life, we must maintain this earnest and organized search for truth. I could base this appeal wholly upon moral and spiritual grounds; the unfolding of beauty, the aspiration after knowledge, the ever widening penetration into the unknown, the discovery of truth, and finally, as Huxley says, " the inculcation of veracity of thought."

No greater challenge has been given to the American people since the Great War than that of our scientific men in the demand for greater facilities. It is an opportunity to again demonstrate in our government, our business and our private citizens the recognition of a responsibility to our people and the nation greater than that involved in the production of goods or trading in the market.

NOTES

A METHOD OF YOKING TWO PAIRS OF BULLOCKS, TANDEM.

In the Madras Presidency, the common method of yoking two pairs of bullocks, tandem, to a heavy implement, is to fasten the rope or chain to the implement, carry it forward to the yoke pole of the hind pair of bullocks and from there to the yoke pole of the front pair. It is also customary to have one man to each pair of bullocks and one man at the implement. As a rule the bullock driver sits perched on the yoke pole of his pair, with his back towards the direction in which they are moving. His duties are to guide the animals, keep them on the move and by his weight keep the yoke pole in position.

The main disadvantages of this procedure are—

(1) Both pairs may not put their weight into the yoke simultaneously, in which case the implement remains stationary, and first one and then the other pair staggers to one side or the other in the vain endeavour to move it.

(2) One pair of bullocks may slack at the expense of the other.

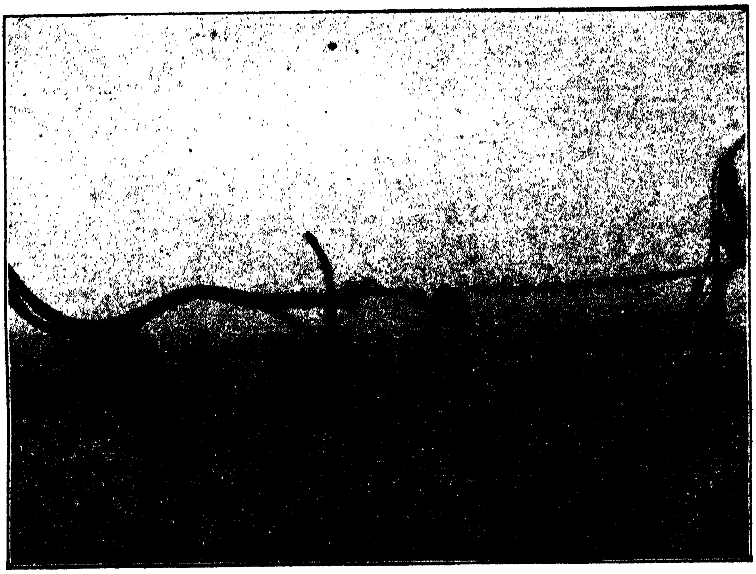
(3) Sore necks are frequent.

(4) It is difficult to keep the implement working along a straight line.

(5) The expenses are high.

On the Cotton Breeding Station at Coimbatore this method of yoking has been replaced by one which is simpler and more efficient. Here, we attach a pulley block to the implement, usually a plough, fasten one end of the chain to the yoke pole of the hind pair of bullocks, pass the chain over the wheel of the pulley and carry it forward, underneath the hind yoke to the yoke pole of the front pair. By this means the evil effects of irregularities of pull are eliminated, for if one pair pulls and the other does not, all that happens is that the slack of the chain is taken up until the non-pulling pair feels a backward draw to which it responds by pulling forward. As soon as both pairs are pulling, but not until, the implement moves forward. The risk of sore necks is minimised and the chances of an animal straining itself by endeavouring to do something which is beyond its powers are eliminated. Instead of a driver to each pair of bullocks a boy is all that is necessary. One pair cannot slack at the expense of the other, for if the front pair endeavour to do so the hind pair run into them from behind, and if the hind pair make the attempt the interval between the pairs increases and the driver applies the necessary correction. This method has been in use on this station for the last three years and has been found to

work satisfactorily. Once the animals have learnt what is required of them they settle down, one pair immediately behind the other, and maintain a steady pull until



Method of yoking two pairs of bullocks, tandem.
The upper part of the chain is fastened to the yoke of the hind pair and the under part to the yoke of the front pair.

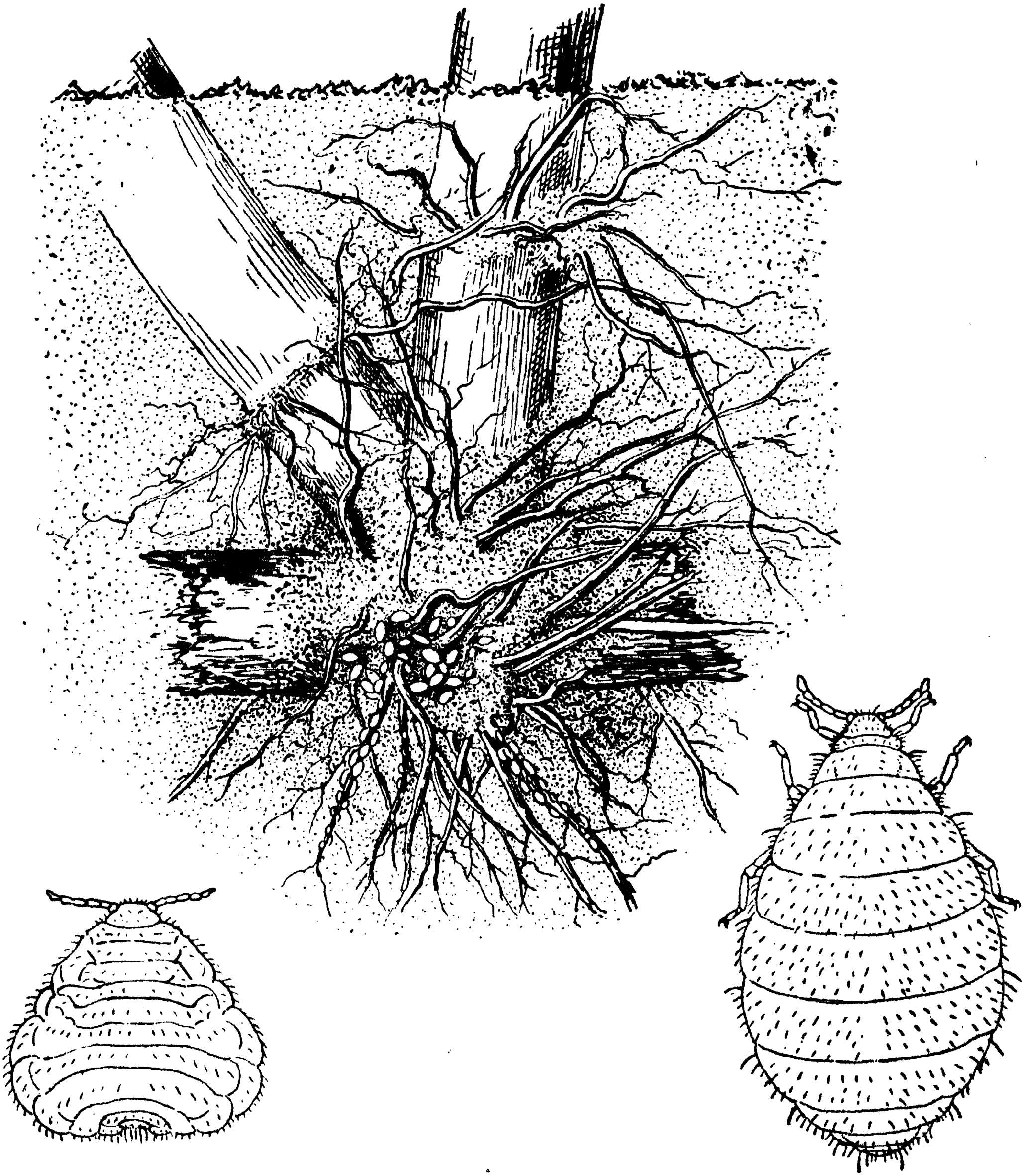
the end of the furrow is reached. As a precaution against the front pair getting too far ahead when turning at the headlands an iron pin is put through a link at a point in the part of the chain between the hind yoke and the pulley, such that when the animals are in position the pin is a few links ahead of the pulley. [G. R. HILSON.]

AN APHIDID, ON SUGARCANE ROOTS, NEW TO INDIA.

IN December 1926, a small greyish wingless Aphidid was found at Pusa, occurring underground on roots of sugarcane. As this insect proved to be new to us, specimens were sent to the Imperial Bureau of Entomology for favour of identification and have been named as *Geoica spatulata*, Theobald.

This insect was originally described from Egypt (*Bull: Soc. Ent. Egypt*, 1922, pp. 73-76, figs. : 1923) where both winged and wingless females were found at Gizeh on the roots of a species of *Panicum*. In his " Notes on the Aphididae of Egypt " (*Agric. Techn. Bull.* 68, p. 47 : 1926) Mr. W. J. Hall further notes that this insect

occurs in Egypt on the roots of wheat, *Cynodon dactylon*, a sedge, and an unknown grass.



An Aphidid (*Geoica spatulata*, Theob.) on sugarcane-roots at Pusa.

Whether this insect will prove to be a pest of sugarcane remains to be seen, but it may be useful to draw attention to its occurrence, as it will probably be found in other places in India.

The illustration shows the wingless females, about natural size, as they occur on the cane roots and the enlarged figures ($\times 16$) show the insect in greater detail. [T. BAINBRIGGE FLETCHER.]

TOPWORKING OF MANGO TREES.

IN "The Agricultural Journal of India," Vol. XV, 1920, Part V, p. 516, there was described a method of topworking mango trees whereby jungly trees or trees of poor variety could be transformed into trees bearing excellent fruits. It may interest readers to know that the tree mentioned in that article as having been topworked in 1913 has given the following yields of fruits :—

Year	No. of fruits	Year	No. of fruits
1916-17	38	1920-21	200
1917-18	372	1921-22	350
1918-19	450	1922-23	500
1919-20	0	1923-24	450

These figures show how successful the topworking has been.

In the process, as described in the article cited, the branches of the jungly tree were lopped to induce new growth on which to graft. Mr. P. G. Joshi, Superintendent of the Ganeshkhind Botanical Garden, Poona, and one of the authors of the said article, has since introduced a refinement, *viz.*, ringing the branches instead of lopping them. Ringing (*i.e.*, removing a ring of bark) induces new growth quite as successfully as lopping, and in addition does not deprive the grafts of the shade and protection of the original foliage. [W. BURNS.]

THE DETECTION OF STALE OR DIRTY MILK.

THERE has for a long time been need for a satisfactory method for examining samples of milk in order to ascertain its cleanliness or its freshness. The application of the so-called reductase-fermentation test seems to give what is required, and the following note upon it, and an account of its application to various types of milk supplied to the public in Poona, may have some value.

If milk is left for 24 hours at a temperature of 100°F. it generally curdles. If it is clean, the curd produced is fine and solid; if it is dirty the curdled milk is spongy. Again, if methylene blue is introduced into milk and the mixture is kept at a tem-

perature of 100°F., the colour gradually disappears by reduction, and the rapidity with which the colour goes depends on the number of reducing bacteria present in the milk. These reducing bacteria are a measure of the contamination of the milk, or in the absence of *serious* direct contamination, of the length of time which the milk has been standing.

Methylene blue tablets* can be purchased for making the test, and one of these is dissolved in 200 c.c. of water. The water should have been previously boiled. One c.c. of this solution is then added to 40 c.c. of milk in an upright tube. The series of such tubes, covered with metal covers, are then placed in a water bath at a temperature of 100°F., and kept at this temperature. The time which is needed for the milk in each tube to become colourless is noted, and at the same time a note is made of any objectionable smell that appears.†

Milk so treated has been classified into four grades—

Grade I.—Where the milk retains its colour for 5½ hours or more. This is very clean and fresh milk.

Grade II.—Where the milk retains its colour for at least two hours but not for 5½ hours.

Grade III.—Where the milk retains its colour for at least 20 minutes but not for two hours.

Grade IV.—Where the milk retains its colour for 20 minutes or less.

If, during the operation, an objectionable smell develops, the milk is lowered by one grade.

The grading of the milk supplied in Poona City by these standards was recently undertaken. Milk was obtained (1) direct from buffaloes kept by private people and milked in the presence of the investigator, (2) from the Agricultural College Dairy immediately after milking the animals, (3) from dairy shops in the city, (4) from buffaloes after milking by milk dealers having animals in the city, (5) from deliveries by city milk dealers at their customers' houses, (6) from buffaloes kept by village milkmen (*gavalis*) immediately after milking in the villages, and (7) from the cows of city milk dealers after standing over night.

The tests were all done in April and the samples were collected early in the morning. In one set 25 per cent. of cold water was added to the milk before testing. All the samples were examined immediately after collection (Table I), after keeping for four hours (Table II), and after keeping for eight hours (Table III).

The following tables and discussion show the results obtained and would seem to indicate the value of the test in picking out stale and dirty milk.

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*The materials and apparatus for making the test can be obtained in a convenient form from Messrs. Sutherland, Thomas & Co., 31, Tooley Street, London, S. E.

† The grades have been suggested by Barthel and Jensen, who have specified the conditions of the test as we have used it.

TABLE I.

Source of milk	No. of samples tested	First Grade	Second Grade	Third Grade	Below Third Grade
		Per cent.	Per cent.	Per cent.	Per cent.
Private animals	4	75	25	..	..
College Dairy	12	58·3	41·7	..	..
City milkmen (*gavalis*)	18	55·5	27·8	16·7	..
City dairy shops	11	18·2	54·5	9·3	18·0
Milk from city milkmen kept over night	6	16·6	83·4	..	..
Milk as supplied at the houses of the customers.	12	8·3	33·4	58·3	..
Village *gavalis*	13	..	58.3	41·7	..
City milkmen's milk with added water 25 per cent.	4	75	25	..	

This table shows that samples from private animals were excellent and those from the Agricultural College Dairy were quite good. The samples from city milkmen were also good though they were not quite so good as those of the first group. Samples from city dairy shops appeared to be of the same type as city milkmen's samples kept over night. This was perhaps due to the fact that the milk at the dairy shops is received by the customers long after it is drawn, or perhaps it is a mixture of fresh milk and milk kept over night. Milk supplied at the houses of the customers was worse than the above samples. This was so perhaps because the milk was mixed and badly handled before delivery. It was, however, surprising to find that the milk of village *gavalis* proved to be of the lowest grade. Where 25 per cent. of cold water was added to city milkmen's milk, the milk improved with regard to its bacterial contents. The cold water added probably prevented the multiplication of the organism.

The above samples were again tested after keeping them for four hours after collection. These were kept in a well ventilated room in bottles with open mouths, to imitate the condition in which milk is generally exposed. The temperature varied between 82° and 88°F. Table II shows the condition of these milk samples.

TABLE II.

Source of samples	No. of samples	First Grade	Second Grade	Third Grade	Below Third Grade
		Per cent.	Per cent.	Per cent.	Per cent.
Private animals	4	..	50·0	50·0	..
College Dairy	12	8·3	25·0	50·0	16·7
City milkmen	18	33·3	38·3	16·3	11·1
City dairy shops	11	..	18·2	59·5	22·3
Milk from city milkmen kept over night	6	..	16·6	83·4	..
Milk as supplied at the houses of the customers.	12	..	8·3	66·7	25·0
Village *gavalis*	13	..	15·4	69·2	..
City milkmen's milk with added water 25 per cent.	4	..	16·6	83·4	..

Only 8·3 per cent. samples of the Agricultural College Dairy and 33·3 per cent. samples from city *gavalis* remained first class after four hours. The percentage of the last grade of samples is distinct in samples from the Agricultural College Dairy, city milkmen, city dairy shops and those supplied at the houses of customers. But on the whole the samples kept fairly well.

The samples were kept further on to test their condition 8 hours after collection. Table III given below shows the results.

TABLE III.

Source of samples	No. of samples	First Grade	Second Grade	Third Grade	Below Third Grade	REMARKS
		Per cent.	Per cent.	Per cent.	Per cent.	
Private animals	4	..	25	75	..	
College Dairy	12		..	16	83·4	
City milkmen	18	..	33·3	33·4	33·3	
City dairy shops	11	..	..	9·0	91·0	
Milk from city milkmen kept over night	6	..	..	..	..	All curdled before testing.
Milk as supplied at the houses of the customers.	12	..	..	25	75	
Village *gavalis*	13	..	1	1	98	

The private milk samples kept well even after 8 hours and the city milkmen's samples also kept fairly well. The city dairy shop samples and samples from village *gavalis* were found below the third grade to the extent of 91 and 98 per cent. respectively.

There was one good point about all these samples. None of them gave any bad smell. Samples which were kept over night were curdled 8 hours after the first test.

In addition to the samples mentioned above, a few were kept in ice boxes before tests were taken. These again pointed to a similar conclusion regarding the general character of the milk from different sources.

TABLE IV.

Source of sample	Temperature	No. of samples	First Grade	Second Grade	Third Grade	Below Third Grade
			Per cent.	Per cent.	Per cent.	Per cent.
City milkmen	59-62°F.	26	96	4	..	..
Dairy shops	58-59°F.	6	50	16·6	33·4	..
Milk stall in market	57-58°F.	8	37·5	37·5	12	13

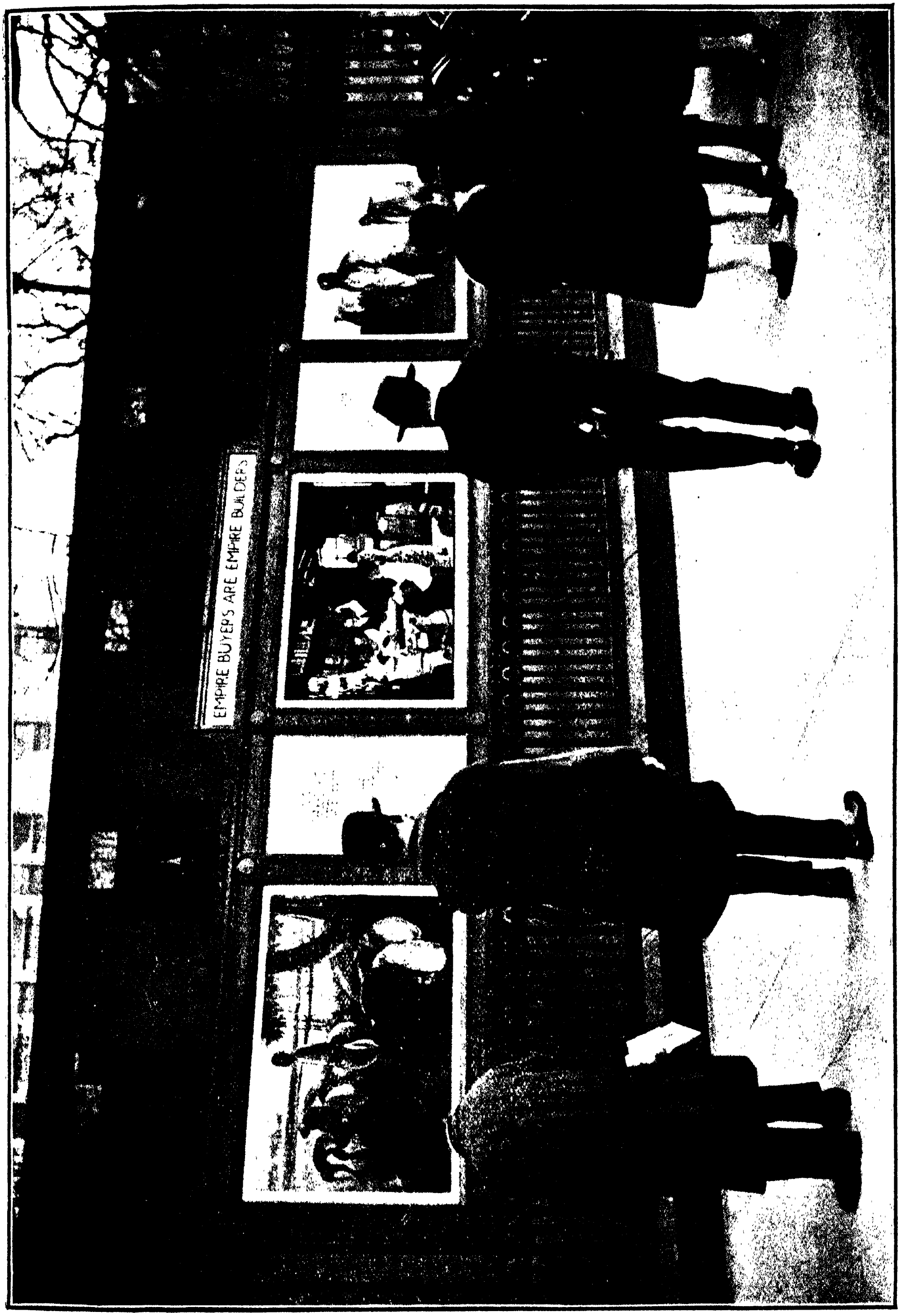
The fresh samples from the animals of city milkmen stood very high and were excellent. Dairy shop samples again were not quite as good as those of the city milkmen, while the samples from milk stalls in the market stood last. [V. N. GOKHALE.]

ADVERTISING EMPIRE GOODS IN LONDON.

PLATE XXXVII is a photograph taken in Whitehall nearly opposite the end of Downing Street. It shows a little group of London citizens inspecting the posters set up in a special frame by the Empire Marketing Board.

The picture on the extreme left shows " The Rice Fields of India " with descriptive letterpress beside it. " A Country Grocer's Shop " is shown in the centre with " The Tea Gardens of Ceylon " and accompanying letterpress on the right flank. Mr. G. Spencer Pryse, M.C., painted the Indian and Ceylon posters and Mr. Fred Tayler, R.I., the centre piece.

This set of posters is being displayed all over London and the largest cities of the United Kingdom and, although the Whitehall site, being at the heart of the Empire, is perhaps unique, the frames are everywhere being erected in especially favourable positions. The object of the display is to bring home to the people of England by vivid pictorial appeal the importance of the work of their fellow British citizens in the Empire overseas.



ADVERTISING EMPIRE GOODS IN LONDON.

amendment will be essential for at present this new Contract is more or less a farce. As at present constituted, it is permissible to deliver American cotton against the Empire Contract, but not Empire cottons against the American Contract.

INOCULATION EXPERIMENTS WITH NEMATOSPORA GOSSYPII.

The following is a summary of an article on the above subject by **Mr. R. W.** Marsh in " Annals of Botany," XL, No. CLX :—

1. The position of *Nematospora gossypii* as a wound parasite of the developing cotton boll has been confirmed. It has been established that this organism is unable to attack unpunctured bolls or to cause injury to mature cotton hairs, and *N. gossypii* has shown no power of destroying cellulose under experimental conditions. The injury caused by the growth of a pure culture of this fungus in the developing lint is not a destruction of the existing cell walls, but appears to be an interference with the subsequent growth and maturing of the cotton hairs, this effect being marked by staining, arrested development, and, probably, premature death of the hairs.

2. Staining, a pathological modification of the cell contents, is produced only as a reaction of living hairs. It has been demonstrated that many agencies other than *Nematospora gossypii* are able to bring about this effect. Examples are given which show that staining results when immature lint is infected by any one of many different saprophytic fungi and bacteria, but the attempts to produce staining by purely physical means gave inconclusive results.

3. A small number of bolls were infected with pure cultures of *Spermophthora gossypii* and of *Nematospora coryli*, and the effect of these organisms on the developing lint was found to be similar in all respects to that produced by *N. gossypii*.

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

MICELLAR STRUCTURE OF CELLULOSE.

An optical study of the sub-microscopic structure of cell membranes undertaken to test the accuracy of Nägeli's micellar theory. The paper deals with the properties of the cellulose micellae including their structure, optical properties and crystal nature, and with the micellar structure of the cell membrane including the arrangement of the micellae in the different membranes. The presence of distinct cellulose micellae is proved ; these are oblong and rod-shaped in structure, strongly anisotropic

and behave optically as rhombic crystallites which exhibit three main indices of refraction, $n\alpha$, $n\beta$ and $n\gamma$; $n\beta$ differs only very slightly from $n\alpha$, so that the cellulose micellae may be regarded as optically positively uni-axial and their refractive indices measured ; the following constants are established :

$$n\gamma = 1{\cdot}549 \qquad n\gamma - n\alpha = 0{\cdot}061.$$
$$n\beta \quad n\alpha = 1{\cdot}533$$

The double refraction 0·061 is nearly seven times that of quartz. Cellulose micellae exhibit normal dispersion of double refraction and are transparent to ultra-violet light. From these results and from previous information regarding their crystal structure available from Röntgen diagrams it is probable that the micellae possess rhombic symmetry, and Nägeli's hypothesis, which requires as structural elements of the membrane oblong, optically anisotropic crystaline micellae, receives confirmation. That the stronger refractive power $n\gamma$ coincides with the long axis of the micellae can be deduced from the fact that their orientation is determined by the optical characters of the membrane ; for instance, in phloem and xylem fibres, the micellae lie completely or nearly axially, but in sieve-tubes, xylem vessels and latex ducts they are oriented more tangentially. Lingin and pectic substances are isotropic although certain hemicellulose are anisotropic. The optical properties of suberised and cutinised tissues are the reverse of those of cellulose and the degree of cutinisation can therefore be determined. Where these tissues and doubly refracting hemi-celluloses are absent, double refraction of membranes indicates the presence of cellulose. [*Jahr. wiss. Bot.*, 1926, **65**, 195-223. ALBERT FREY.]

DIAMETER, STRENGTH AND LINT INDEX CORRELATIONS OF COTTON HAIR.

In investigations in North Carolina, acid delinted seed germinated first, those rolled in ashes second, normal seed third and seed treated with sodium nitrate last. The treatments ranked in the same order in regard to number of open bolls per acre and yield of seed-cotton per acre. Considerable differences were found in the average diameters and breaking loads of hairs from Cleveland, Mexican Big Boll, King, Cook and Rowden cottons grown under the same conditions. Diameter and breaking load are directly related and Mexican Big Boll gave the highest and Cleveland the lowest values. The correlation between diameter and breaking load for all varieties was $r = +0{\cdot}623 \pm 0{\cdot}013$. As the density of hairs on the seed coat increases, hair diameter, lint index and percentage of lint increase and hair length and weight of seed decrease. Increase in length is associated with increased lint percentage and decreased diameter. The correlation between length and diameter is $-0{\cdot}02929 \pm 0{\cdot}0356$, and between hair length and lint percentage is $-0{\cdot}265 \pm 0{\cdot}03621$. Increase in size of seed is slightly associated with greater hair length, $r = +0{\cdot}11303 \pm 0{\cdot}03845$. Increased density of hairs on the seed-coat is definitely associated with an increased number of convolutions per inch and increased hair length is associated with a decrease in the number of convolutions per inch. In halved hairs, the end

attached to the seed was found to have the smaller number of convolutions per inch. [*Expt. Sta. Rec.* 1925, **53**, 736 ; from *North Carolina Sta. Rpt.*, 1924, 31-34, 37, 38. R. Y. WINTERS.]

SIZE VARIATIONS OF COTTON POLLEN GRAINS.

Differences in pollen grain size are characteristic of different varieties of cotton. The pollen grains of Upland and Indian varieties are the smallest whilst those of Egyptian (Pima) and Marie Galante are the largest. No correlation apparently exists between chromosome number and pollen grain size. The F_1 hybrid shows the pollen dimensions of the large pollen parent. The variation in the size of pollen from different varieties is continuous, from 108μ to 135μ. Pollen grain size is least variable in Indian with a coefficient of variability of 4·35, and most variable in the hybrid Mead by Sea Island with a C. V. of 7·64. Bourbon (probably *G. purpurescens*, or a variety of this species) is morphologically closely related to Upland and possesses pollen grains of practically the same dimensions. *G. brasiliense*, which belongs to the same group as Sea Island, also possesses pollen grains of practically the same size, the frequency curves possessing a mode of 2·3 in both cases. [*Empire Cotton Growing Review*, 1925, **2**, 348-352. HERBERT MARSLAND.]

TRANSPIRATION.

To test the general assumption that evaporation in moving air increases proportionally with the area of the evaporating surface, the authors used card-board models of geometrical figures or cut into large and small leaf forms (*Aristolochia sipho* and *Vitis virnifera*) to test the above relationship under natural climatic conditions. Although wind force, temperature and humidity were very variable, there was evidence, with the geometrical forms, and contrary to expectation, of a significant regularity : the amount of water evaporated was strictly proportional to the 1·6-1·7 power of the linear dimensions or to the 0·80-0·85th power of the area. The results were essentially the same in the air circulation of a large room. The relation does not hold, however, when comparing such different leaf forms as those of *Aristolochia* and *Vitis* ; the more divided is the leaf form the greater is the evaporation even in strong currents of air. In this case evaporation is not proportional to the surface area but is dependent on the shape of the surface and the direction in which the wind strikes the surface. Accordingly, it is not possible to compare the transpiring power of leaves by calculating evaporation per unit of surface area. The water given off by 1 g. of the fresh transpiring organ is the most convenient figure to use in transpiration comparisons. The author's conclusions are in agreement with Stocker's transpiration measurements, of which a number are tabulated in the paper, and with Jeffrey's results obtained mathematically. [*Z. Botanik*, 1925, **18**, 1-47. HEINRICH WALTER.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

His Majesty the King-Emperor's Birthday Honours List contains the following names :—

K. C. S. I.—The HON'BLE KHAN BAHADUR SIR MUHAMMAD HABIBULLAH, K.C.I.E., KT., Member of the Governor-General's Executive Council.

O.B.E.—MR. T. F. MAIN, Deputy Director of Agriculture, Bombay.

Rao Bahadur.—RAO SAHIB M. R. RAMASWAMI SIVAN, Principal, Agricultural College, Coimbatore.

Khan Sahib.—MUNSHI TALIB KHAN, Deputy Superintendent, Civil Veterinary Department, Punjab.

CHAUDRI GHULAM HASSAIN, General Manager, Rustam Farm, Department of Agriculture, Iraq.

MR. NAWAB ALI, Veterinary Assistant, Andamans.

Rai Sahib.—MR. GAURI SHANKAR, Deputy Superintendent, Civil Veterinary Department, Central Provinces.

MR. A. R. DALAL, I.C.S. (Bombay), has been appointed to officiate as Secretary to the Government of India, Department of Education, Health and Lands, *vice* Mr. J. W. Bhore, C.I.E., C.B.E., I.C.S., granted leave.

MR. M. I. RAHIM, I.C.S. (Central Provinces), has been appointed to officiate as Under Secretary to the Government of India, Department of Education, Health and Lands, *vice* MR. M. S. A. Hydari granted leave.

DR. W. MCRAE, M.A., F.L.S., has been confirmed in the appointment of Imperial Mycologist, *vice* Dr. E. J. Butler, C.I.E., F.R.S., permitted to retire from the Indian Agricultural Service.

MR. W. J. JENKINS, M.A., B.SC., Deputy Secretary, Indian Central Cotton Committee, has been appointed Officiating Director of the Institute of Plant Industry, Indore, *vice* Mr. A. Howard, C. I. E., granted leave.

MR. J. H. RITCHIE, M.A., B.Sc., Deputy Director of Agriculture, Northern Circle, Central Provinces, has been appointed Officiating Deputy Secretary, Indian Central Cotton Committee, *vice* Mr. W. J. Jenkins on other duty.

MAJOR R. F. STIRLING, F.R.C.V.S., D.V.S.M., Second Superintendent, Civil Veterinary Department, Central Provinces, has been appointed Officiating Pathologist at the Imperial Veterinary Research Institute, Muktesar.

MR. C. TADULINGA MUDALIYAR, F.L.S., Government Lecturing and Systematic Botanist, has been appointed Prinicipal of the Agricultural College, Coimbatore, from the date of retirement of Rao Bahadur M. R. Ramaswami Sivan.

MR. D. G. MUNRO, B.Sc., Deputy Director of Agriculture, Madras, on reversion from the United Planters' Association of Southern India, has been posted to the VII Circle, Coimbatore.

MR. M. CARBERY, M.A., B.Sc., Agricultural Chemist, Bengal, has been allowed leave for six months from 1st June, 1927.

MR. G. C. SHERRARD, B.A., Deputy Director of Agriculture, Bihar and Orissa, has been granted leave for nine months from 16th May, 1927.

MR. C. H. PARR, B.Sc., Deputy Director of Agriculture in charge of Cattle-breeding Operations, United Provinces, has been granted leave for five months from 1st June, 1927. Saiyid Muhammad Raza Husain has been placed in charge of Mr. Parr's duties during the latter's absence.

MR. H. R. STEWART, F.R.C. Sc.I., D.I.C., N.D.A., Professor of Agriculture, Lyallpur, has been appointed to officiate as Director of Agriculture, Punjab, *vice* Mr. D. Milne, C.I.E., granted leave for 8 months from 9th May, 1927.

ON return from leave, Mr. R. Watson, N.D.A., has been posted to Akyab as Deputy Director of Agriculture, Arakan Circle, Burma.

REVIEWS

Studies of the Pink Bollworm in Mexico.—By W. OHLENDORF. U. S. DEPT. AGRIC. BULL. 1374 ; pp. 64, 15 FIGS. ; MARCH 1926 (RECD. FEBRUARY 1927).

The literature on the Pink Bollworm is already large and the present publication forms a notable contribution as it deals with the occurrence of this insect in Mexico, in a very dry area, the average rainfall being only about 8 inches and cotton production being only possible by irrigation, so that the conditions form a close parallel to those of many cotton districts in North India. Under these onditions it is of interest to study the behaviour of the Pink Bollworm in its new home in the New World ; for it must be remembered that this moth was first described from India, which is evidently its original home, and that it has been introduced with cotton-seed into practically all the cotton-growing regions of the World, so that it is now known from Palestine, Iraq, Siam, Straits Settlements, China, Japan, Korea, Philippines, Hawaii, Egypt to Zanzibar, West Africa, Brazil, West Indies, Mexico, Southern United States, and Australia.

Careful studies are given here of the life-history of this insect, and it may be stated briefly that this corresponds closely under Mexican conditions to those noted in India. The larvæ enter the soil, for pupation, to a depth of at least six inches, and long-cycle larvæ occur, the maximum longevity being found to be 16¾ months.

Experiments on the range of flight of the moths showed that a distance of 8 miles is not sufficient to secure immunity. In experiments in which cotton was infested at distances of 25 and 40 miles, the infection was perhaps carried by human agency (infested cotton) and not by flight, although the factor of flight was not excluded.

Two parasites, *Microbracon mellitor*, Say, and *Habrobracon gelechiæ*, Ashm., were found to attack the larvæ.

Experiments on the treatment of seed by heat showed that cotton-seed can be disinfected by exposure to dry heat at 145°F. for 3½ minutes, and that treatment by live steam is also quite effective if the seed is discharged at a temperature of not less than 145°F. after an exposure of not less than one minute, during the first half of which it is subjected to steam, the remaining time being allowed for the penetration of the heat to the larvæ inside the seed.

This Bulletin should be in the hands of all interested in Pink Bollworm in India.
[T. B. F.]

The Palms of British India & Ceylon.—By ETHEBERT BLATTER, S. J., Ph. D., F.L.S. Pp. XXVIII + 600; CVI plates; 49 text-figs; 2 maps. (Oxford University Press.) Price Rs. 30.

Father Blatter's reputation as a botanist is a sufficient guarantee of the value of this work. The book is a survey of the whole range of palms growing in British India and Ceylon, including foreign species growing under cultivation and for ornamental purposes.

The book consists of an introductory chapter containing a general account of the biology and distribution of the palms followed by five chapters on classification, each chapter being devoted to one of the major taxonomic divisions. The illustrations are numerous and form an attractive feature of the work—it is a pity that in some cases the reproduction is poor. There is a botanical description of each genus and species followed by an account of the distribution and uses of the tree. To the general reader the sections dealing with the commercial products of palms and the native folklore, which has accumulated about the most important species, will prove of greater interest than the taxonomy. There is a comprehensive bibliography and index. [F. J. F. S.]

A Tea Manual for Beginners.—By J. W. S. (Published by the Ceylon Advertising Co., Ltd., Colombo.) Price Rs. 7·50.

While there are better all round books on the subject of tea planting, this is quite a sound one for young tea planters as it contains much practical and detailed information which can be usefully employed.

There are several points, however, to which exceptions may be taken. Under the heading " Drains " the writer states, " It is fundamentally important because the purpose of drains is to conserve the soil." The purpose of drains is to drain the soil, and there is evidently confusion in the author's mind between drains proper and soil conservation trenches which on occasions of heavy rainfall may also have to cope with a rush of surface water. The former may have to be dug on the flat where there is little possibility of soil wash, while the latter very often have to be dug for the prevention of soil wash even when natural drainage is quite efficient.

With regard to the disposal of earth from the trenches, the writer says (page 16), " The earth which is cut out of drains should be thrown far off on the lower side of the slope and afterwards well raked down so that it will not fall back into the drains; thus no earth bank will be formed on the lower side." The next heavy thundershower will probably wash a certain proportion of this soil into the trench below and it is only a question of time before this soil reaches the bottom of the hill. Would it not be preferable, therefore, to put it, where possible, on the top side or to form a bank of earth on the lower side of the trench and kept in position and consolidated by growing a green manure or cover crop on it ? This would not only give a small

amount of organic matter, but would also help to prevent the overflowing of these trenches as mentioned on page 14.

Very often when putting out well grown basket plants (p. 34) it is found that the tap roots of the young plants have penetrated through the bottom of the baskets. The bottoms of the baskets should be slit off with a sharp knife by running it round the edge and the tap roots pruned back, so that there will be no chance of their being bent during the process of planting.

In other cases it is found that the tap roots have been bent inside the basket due to the resistance offered by the bottom. It is, therefore, advisable in all cases to slit off the bottoms of the baskets and make certain that the tap roots are not bent.

In the chapter on Topping or Centering (p. 39) the writer states, " The cut should be made 18″ from the ground," and further on " any side branches there may be below the 18″ limit should be cleanly cut off in the same manner." While bushes pruned in this manner do give a bigger yield in the first few years of plucking, they generally develop into the " Champagne glass " type later on. They are altogether more difficult to prune later on than bushes initially centred at 2′-6″ from the ground are. Not only so, but with the method of plucking advocated on page 52, where " one mature leaf should always be left above the fish-leaf," on a 3-year rotation, the 18″ topped bushes must be almost if not quite out of reach of the pluckers by the time the 3 years are up.

The chapter on manuring might usefully contain a paragraph on the unit values of the manures.

It is evident from the second part of the book that the writer has spent a considerable time in perfecting manufacture. This is undoubtedly the most serviceable portion of the book. The different processes of manufacture are treated in detail from a practical point of view. [D. G. M.]

Improved Agriculture and other allied Scientific Subjects (in Sindhi).—By MANOHAR DASS KAURAMAL, B.A.

The book is divided into three parts but the subjects dealt with are not systematically arranged. The author has embodied in it his experience of zemindari life as well as some agricultural methods practised in other parts of India. He tells what seeds are good, what manures to use and what improved methods of tillage to adopt, and how to propagate some fruit trees and flower plants. There are also chapters on the preservation of seed, on green-manuring and on simple methods of " kalar " reclamation. The book seeks to awaken interest in the minds of the young generation for scientific agriculture as a profession. [G. M.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Farm Projects and Problems, by K. C. Davis. (London: J. B. Lippincott.) Price, 8*s*. 6*d*.
2. Plant Ecology, by W. B. McDougall. (London: Kimpton & Co.) Price 14*s*.
3. Animal Nutrition and Veterinary Dietetics, by R. G. Linton. Pp. 411. (Edinburgh: W. Green.) Price, 21*s*.
4. Potato Varieties, by R. N. Salaman. (Cambridge University Press.) Price, 25*s*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:

Memoirs

1. Studies in Gujarat Cottons, Part IV: Hybrids between Broach-deshi and Goghari varieties of *Gossypium herbaceum*, by M. L. Patel, M.AG., and S. J. Patel, B.AG. (Botanical Series, Vol. XIV, No. IV.) Price, As. 14 or 1*s*. 6*d*.
2. Some Digestibility Trials on Indian Feeding Stuffs II, by P. E. Lander, M.A., D.Sc., A.I.C., and Pandit Lal Chand Dharmani, L.AG., B.Sc. (Ag). (Chemical Series, Vol. IX, No. III.) Price, As. 10 or 1*s*.
3. The Effect of Manuring a Crop on the Vegetative and Reproductive Capacity of the Seed, by B. Viswa Nath, F.I.C., and M. Surianarayana, B.Sc. (Chemical Series, Vol. IX, No. IV.) Price, As. 14 or 1*s*. 6*d*.

4. Sampling for Rice Yield in Bihar and Orissa by J. A. Hubback, I.C.S. (Pusa Bulletin No. 166.) Price, As. 7 or 9*d*.
5. A Scheme of classification of the varieties of Rice found in Burma, by R. A. Beale. (Pusa Bulletin No. 167.) Price, As. 6 or 8*d*.

Report

6. Annual Report of the Imperial Institute of Veterinary Research, Muktesar 1925-26. Price, As. 8 or 10*d*.

ORIGINAL ARTICLES

THE LOCUST ATTACK OF 1926-27 IN SIND, KATHIAWAR AND GUJARAT.

BY

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AND

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From October 1926 until February 1927 swarms of the North-West locusts appeared in Sind and did considerable damage.

From December 1926 till February 1927 similar attacks occurred in Kathiawar and in Northern Gujarat.

Our account of these attacks is necessarily faulty due to the very fragmentary information received. One of the objects of this report is to ensure that, in any succeeding attack, information shall be immediate and complete. In point of time the earliest notice we had of the attack under discussion was a report of the appearance of locusts on 25th September, 1926, at Sujawal, Jati, and Shah Bunder in the Karachi District. The Deputy Collector, Tatta, Karachi District, reported on 3rd November to the Collector of Karachi that locusts, still in the hopper stage, had been noticed all round the Karachi Taluka and that they were in abundance in the *dehs* near the Hab river. The Collector, in passing on this information to the Deputy Director of Agriculture in Sind, said that his information was that the hoppers were advancing from the sandy bed of the Hab river. On 16th November the Deputy Director of Agriculture in Sind reported that the locusts had developed wings and become scattered. This is the only available report describing any locusts actually in the hopper stage.

After this, reports of locust swarms were received from many places in Sind. The attack in Kathiawar appears to have started later and was not reported until December, several villages in the Katosan Thana of the Mahi Kantha Agency having been affected on 14th December. Attacks continued until about the end of February and then ceased in both Sind and Kathiawar.

The following table will give a very rough idea of the intensity of locust attack in the various months.

TABLE I.

Month	Number of attacks reported	
	Sind	Kathiawar and Gujarat
September 1926	2	..
October 1926	11	..
November 1926	30	..
December 1926	22	41
January 1927	42	73
February 1927	26	14
March 1927	..	1

We fully recognize that the paucity of our information renders the table very rough but associated with the statements of various observers we conclude that the attacks gradually increased, reached their climax as regards frequency in December 1926, and then decreased, ceasing in February 1927.

PLACES OF ORIGIN OF THE LOCUSTS.

We have already stated that hoppers were observed advancing from the sandy bed of the Hab river near Karachi, and we may assume that this was *one* breeding place. It was not, however, the only one. Previous experience shows that the Sind-Rajputana desert is a fertile breeding place of locusts, and the District Agricultural Overseer, Nawabshah, states that the locusts affecting his district came from the Thar Parkar District which is a portion of the desert above mentioned. He states that the locusts finally returned there to lay eggs but he does not state that egg-laying was actually observed. It is very difficult to decide whether the locusts which visited Kathiawar and Gujarat were from either of these origins. It is a fact that Eastern Kathiawar and the neighbouring talukas of Northern Gujarat and particularly the northern part of these areas were badly affected by locusts. This may have been due to an invasion coming from Thar Parkar passing the eastern end of the Rann of Cutch and so into Kathiawar.

We have no definite records of locusts arriving by sea, but the appearance of locusts at Porbandar on the eastern coast of Kathiawar and adhering to the coast for some time may point to a flight having come from Karachi partly across the sea. The Bombay Steam Navigation Company and the British India Steam Navigation Company both kindly instructed the commanders of their ships to report to us any flights of locusts over the sea, but no such reports were received by us. It is possible, of course, that there may be many more breeding places from which the present attack occurred, but these are only two of which there is definite observation.

MOVEMENTS OF LOCUSTS.

Here again we were badly handicapped by insufficient information although this had been asked for from all the authorities concerned in Kathiawar and Gujarat. Our general impression is that there were many locust swarms. Whether these were originally separate or whether they split or recombined we cannot tell, but that there were several swarms appearing simultaneously is without doubt. A study of the following Tables II and III and particularly of dates such as 13th November 1926 in Sind and 5th January, 1927, in Gujarat and Kathiawar shows this clearly.

TABLE II.

Sind : Locust attacks reported.

Date	Place
September 25	Karachi, Thar Parkar.
October 1	Karachi.
,, 2	Karachi.
,, 9	Karachi.
,, 11	Karachi.
,, 12	Karachi.
,, 16	Karachi, Hyderabad.
,, 23	Karachi, Hyderabad.
,, 30	Thar Parkar.
,, 31	Thar Parkar.
November 3	Karachi.
,, 6	Thar Parkar.
,, 7	Nawabshah, Hyderabad.
,, 8	Upper Sind Frontier, Nawabshah.
,, 9	Larkana, Nawabshah.
,, 10	Upper Sind Frontier.
,, 11	Upper Sind Frontier, Nawabshah.
,, 12	Larkana, Nawabshah.
,, 13	Karachi, Nawabshah, Larkana, Hyderabad, Thar Parkar.
,, 14	**Karachi.**
,, 16	**Larkana.**
November 20	Karachi, Hyderabad.
,, 24	Karachi.
,, 25	Karachi, Nawabshah.
,, 26	Nawabshah.
,, 27	Hyderabad, Nawabshah.
,, 28	Upper Sind Frontier.
,, 30	Thar Parkar.
December 2	Nawabshah
,, 4	Karachi, Thar Parkar. Nawabshah.
,, 6	Karachi.
,, 8	Thar Parkar.
,, 10	Karachi.
,, 12	Karachi.
,, 13	Nawabshah, Karachi.
,, 14	Karachi.
,, 15	Karachi.
,, 16	Larkana.
,, 17	Karachi, Larkana
,, 18	Thar Parkar, Karachi, Larkana.
,, 20	Thar Parkar.
,, 22	Thar Parkar.
,, 25	Karachi, Hyderabad
January 4	Thar Parkar.

TABLE II—*concld.*

Sind : Locust attacks reported—concld.

Date		Place
January	5	Thar Parkar.
,,	8	Thar Parkar.
,,	12	Nawabshah
,,	13	Nawabshah.
,,	14	Karachi.
,,	15	Hyderabad, Thar Parkar, Nawabshah, Karachi.
,,	16	Nawabshah.
,,	17	Sukkur.
,,	18	Sukkur, Larkana.
,,	19	Nawabshah, Sukkur.
,,	20	Larkana, Thar Parkar, Nawabshah, Sukkur.
,,	21	Larkana.
,,	22	Thar Parkar, Larkana.
,,	23	Sukkur, Larkana.
,,	24	Larkana.
,,	25	Sukkur, Larkana.
,,	27	Sukkur, Larkana.
,,	28	Karachi, Larkana, Sukkur, Upper Sind Frontier.
January	29	Karachi, Thar Parkar, Nawabshah, Larkana, Sukkur.
,,	30	Larkana, Sukkur.
,,	31	Larkana.
February	1	Sukkur.
,,	3	Larkana.
,,	4	Larkana, Sukkur.
,,	5	Karachi, Hyderabad, Thar Parkar, Nawabshah, Sukkur, Upper Sind Frontier.
,,	7	Sukkur.
,,	8	Sukkur.
,,	10	Karachi.
,,	11	Thar Parkar.
,,	12	Karachi, Hyderabad, Thar Parkar, Nawabshah, Sukkur, Upper Sind Frontier.
,,	13	Upper Sind Frontier.
,,	19	Karachi, Hyderabad, Larkana, Sukkur, Nawabshah.

TABLE III.

Gujarat and Kathiawar : Locust attacks reported.

Date		Place
December	7	Broach.
,,	9	Banaskantha Agency.
,,	10	Mahikantha, Western Kathiawar Agency.
,,	11	Western Kathiawar Agency, Mahikantha and Jhinjhuwada Thana.
,,	12	Ahmedabad, Western Kathiawar Agency.
,,	14	Mahikantha, Ahmedabad, Banaskantha.
,,	15	Mahikantha, Ahmedabad, Kanthad Vala State.
,,	16	Mahikantha, Ahmedabad.
,,	17	Ahmedabad, Jhinjhuwada Thana.
,,	18	Western Kathiawar Agency, Dhrol State.
,,	19	Dhrol State
,,	20	Ahmedabad, Dhrol State, Jetpur, Sardarghad.
,,	21	Ahmedabad, Navanagar, Dhrol State.
December	22	Eastern Kathiawar States, Navanagar State, Dhrol State and Western Kathiawar Agency.
,,	23	Kanthad Vala State.
,,	27	Dhrol State.
,,	30	Porbandar, Sorath, Banaskantha.
,,	31	Porbandar, Ahmedabad, Jetpur.
January	1	Porbandar.
,,	2	Porbandar, Mahikantha.
,,	3	Ahmedabad.
,,	4	Mahikantha, Ahmedabad.
,,	5	Bhavnagar, Morvi, Sorath, Baroda State, Navanagar State, Mahikantha and Western Kathiawar Agency.
,,	6	Ahmedabad, Mahikantha, Bhavnagar.
,,	7	Bhavnagar.
,,	8	Bhavnagar, Dhola, Panch Mahals.

TABLE III—*concld.*

Gujarat and Kathiawar : Locust attacks reported—concld.

Date		Place	Date		Place
January	9	Bhavnagar, Vakaner, Mahikantha.	January	25	Junagad.
,,	11	Bhavnagar.	,,	26	Junagad, Ahmedabad, Mahikantha.
,,	12	Bhavnagar, Broach.	,,	27	Mahikantha, Ahmedabad, Junagad.
,,	13	Bhavnagar, Mahikantha, Halar, Kantha Vala State.	,,	28	Mahikantha, Ahmedabad, Junagad.
,,	14	Halar, Navanagar State, Kanthad Vala State.	,,	29	Ahmedabad, Junagad, Broach.
,,	15	Halar, Kanthad Vala State.	,,	30	Junagad, West Khandesh.
,,	16	Bhavnagar, Eastern Kathiawar State, Mahikantha.	,,	31	Junagad, Mahikantha.
,,	17	Panch Mahals, Bhavnagar.	February	2	Ahmedabad.
,,	18	Panch Mahals, Bhavnagar.	,,	3	Ahmedabad.
,,	19	Bhavnagar.	,,	5	Mahikantha, Himatnagar.
,,	20	Bhavnagar.	,,	6	Broach.
,,	21	Bhavnagar.	,,	9	Mahikantha, Idar State.
,,	22	Bhavnagar, Eastern Kathiawar States, Junagad.	,,	10	Mahikantha, Idar State.
,,	23	Bhavnagar, Eastern Kathiawar States, Broach, Junagad.	,,	11	Ahmedabad.
,,	24	Eastern Kathiawar States, Mahikantha, Junagad, Panch Mahals.	,,	12	Ahmedabad.
			,,	13	Ahmedabad.
			,,	19	Ahmedabad.
			,,	24	Panch Mahals.
			March	20	Surat.

We have no means of ascertaining whether the same swarm visited a place more than once. In fact, we have no really reliable information as to the movements of any swarm. To keep in touch with a swarm requires an observing and reporting organization that does not at present exist. Within the areas which we are describing the direction of flight of swarms varied a great deal ; sometimes they came from one point of the compass and sometimes from another. We had hoped that the February reports would show a definite drift in one direction, but with the exception of a doubtful northerly and north-easterly movement in Sind, we got few data regarding the direction of the final flight.

SIZE OF SWARMS.

Here again reports are rather vague, but the majority of swarms reported were large. The swarm actually seen by one of us (W. Burns) at Porbandar on 31st December, 1926, was conservatively estimated by the Port Officer, Porbandar, to be five miles long. It was about half a mile broad and 12 feet thick, and contained, at a very rough estimate, over thirty million locusts. Swarms of from one to six miles in length and of variable breadth appear to have been common. Another swarm observed in Central Sind (Sakrand) in the middle of November 1926, was $1\frac{1}{2}$ miles broad, moved constantly westward towards the Indus, and took two

hours to pass over at a computed rate of two to three miles per hour, the insects being very thick during most of the time. This swarm must have been five to six miles long.

FEEDING HABITS.

It has been the custom to state that locusts devour every green thing in their path. Observations made during the attacks now discussed show that this is not necessarily always the case. One of us (H. H. Mann) in a note published in "The Bombay Natural History Society's Journal" drew attention to certain facts regarding the feeding habits observed in Central Sind (at Sakrand) on jungle trees. There the locusts settled most abundantly on the leafless and thorny shrub *Capparis aphylla* and stripped it of its succulent green outer portion. *Khabhar* or *jhar* (*Salvadora* species) was also occasionally attacked, the young shoots on some trees only being completely defoliated. Many *jhar* trees were left almost untouched. The *babul* (*Acacia arabica*) and the *kandi* (*Prosopis spicigera*), both valuable fodder trees, were scarcely attacked. The same was the case with the species of *Tamarix* (*lai*). At Porbandar, one of us (W. Burns) observed that the *Casuarina* trees were heavily attacked in the same manner as the *Capparis aphylla* in Sind. Coconut palms suffered little. *Calotropis gigantea* and *Ipomea pes-caprae* suffered not at all. Mr. B. B. Vaidya of Porbandar very kindly sent the following list of plants observed by him as damaged and undamaged during this attack.

Damaged	*Undamaged*
Casuarina equisetifolia	*Ixora parviflora*
Terminalia catappa	*Tecoma stans*
Thespesia populnea	*Mimusops elengi*
Ficus religiosa	*Melia azadirachta*
Poinciana regia	*Nerium odorum*
Millingtonia hortensis	*Croton*
Ficus indica	*Solanum nigrum*
Bongainvillia spectabilis	
Mangifera indica	
Jasminum sambac	
Murraya koenigii	

The same observer also stated that he found locusts eating their own dead, four or five being engaged in devouring one corpse.

All crops suffered, sometimes severely.

Wheat, rapeseed, *jowar* (*Sorghum vulgare*), cotton, castor, and also mango blossom were damaged in Kathiawar and Gujarat.

In Sind cotton, sesame, *jowar*, *jambo* (*Brassica*) gram, vetch, and wheat were damaged.

There was no standing *crop* in any attacked area that was left absolutely untouched.

Severity and extent of attacks.

The severity of attacks was variable. Occasionally the locusts halted only for a short time and then damage was slight. Thus three successive visitations in the Bhorka Thana of the Eastern Kathiawar Agency in the month of January were reported as resulting in little damage. In the taluka of Sudasna, in the Gadhwada Thana Circle of the Mahikantha Agency, the locusts on 16th January stayed a night in trees and on fallow land, going on next morning without damaging crops. At Mandal, however, also in the month of January the damage to cotton, wheat and rape was estimated at from 50 to 60 per cent., but it is not definitely stated that this is the result of *one* attack. At Viramgam, however, one of our departmental cotton breeders, in a detailed account of a personally observed attack, states that a swarm of three miles long, 50 feet broad, and about four feet deep, during the period 5-10 P.M. to 6-15 P.M. damaged 10 acres *jowar* to the extent of 10 per cent. At Sakrand during 10th and 11th November the damage was estimated as cotton 6 annas, sesame 4 annas, *jowar* one anna, rape, *jambo* and gram one anna. Generally speaking, where locusts merely halted for the night, damage was insignificant, but where they settled during the day damage was greater, up to at least 50 per cent. We have, of course, to take into account that cultivators naturally did what they could to scare away the locusts, and hence the possible damage was reduced. Of the extent of the attacks our figures are undeniably deficient, but the statistics we have actually collected indicate a total area of 82,000 acres damaged in Sind, and an area of 15,000 acres damaged in Gujarat and Kathiawar. These figures were compiled in May 1927 after sending out special enquiry forms very widely. We may assume that 20 per cent. can be added to these figures.

In Gujarat and Kathiawar the main attacked area was in Eastern Kathiawar and the adjoining British districts. Locusts, however, were reported as far south as Broach on 29th January.

Methods of defence actually employed against locusts.

At Porbandar nothing stopped the locusts from coming over, but the beating of kerosene tins, firing of shots, and movement of people prevented their settling. How far mere sound prevents their settling is doubtful. The movement of people probably does as much. However, beating drums is helpful psychologically, in giving a cause for movement, in keeping up the people's spirits, and in its intuitive associations. Similar methods with the addition of smoke fires and the waving of cloths were successful in changing the direction of locusts at villages in the Katosan Thana in the Mahikantha Agency in attacks dating from 14th December to 27th January. The Cotton Breeder, North Gujarat, reports that smoke and drums had no effect on the locusts up till 9-30 A.M. on February 11 at Viramgam, the locusts still being comatose after the cold night. We have on the whole very few data regarding defensive measures taken, their success or failure, but such reports as we have and our own personal observations indicate that once a swarm settles, the

game is up. It is necessary to mobilise every man, woman and child to *prevent* settling. The really weak point of the winged locusts as observed by us is their inertness at night. They can then be killed by the thousand by mere beating down, trampling, burning or other mechanical means.

SUMMARY.

Locust swarms appeared in Sind from September 1926 to February 1927 and in Kathiawar and Gujarat from December 1926 to February 1927. Several swarms operated in both areas, travelling erratically. Many places were repeatedly visited, though there is no evidence that a given swarm visited the same place repeatedly. The only observed place of origin of these locusts, was the Hab river bed near Karachi, but the desert areas of Thar Parkar are also a possible source. The extent of attack is reported as 82,000 acres in Sind, and 15,000 acres in Kathiawar and Gujarat. All crops suffered, but the locusts showed definite preferences as regards wild plants. The traditional methods of defence against the locusts were employed by cultivators in some places, with some success. The attack was at its worst everywhere in December and died away in February. Information as to the final direction of flight is wanting.

CONCLUSIONS.

There are one or two points that emerge prominently. These are—

(1) the entire lack of information as to the appearance of locusts in the hopper stage with the one exception of the Hab river at Karachi;

(2) the lack of information as to the movements of a particular swarm and of the final movements of the locusts (and hence no information as to where they went to lay eggs);

(3) the general helplessness of the population due to lack of information regarding swarms and of organization to deal with them.

There is no difficulty in dealing with locusts if they can be attacked in the egg or hopper stage. Once they have got wings, they are uncontrollable. Considering the speed with which they move, the great distances they cover, the many differently ruled territories they traverse and invade, it seems to us that nothing less than a Government of India organization is capable of dealing with this menace. An information service is the first essential. Afterwards must come organization of parties for dealing with eggs and hoppers and last of all both information (necessarily telegraphic) and organization to defend crops after swarms are actually on the way. Much can be done by organization as was abundantly proved by the success of the Bombay Government in dealing with the Bombay locusts in 1904-05.

NOTE.—The urgency of the problem is indicated by the fact that after the above article was written a widespread and severe attack of North-West locusts occurred and continued at least up till June 1927 in Sind, especially in Eastern Sind. The appearance of these locusts at this season in Sind is unusual, and if these lay their eggs and produce further swarms there is a black look-out for both *kharif* and *rabi* crops of this year.

THE ACCLIMATIZATION OF IMPORTED STOCK.

BY

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An eminent agricultural authority communicated to me some time ago that if an imported bull survived to serve forty cows in the valuable foundation and experimental herd of which he had charge, he felt satisfied with the enterprise. The considerable risk run by imported animals as reflected by this statement would be laid undoubtedly to the charge of the difficulty of acclimatization. What is this perplexing phenomenon? The casual observer will interpret it undoubtedly as the process by which a human being or an animal adapts itself to a new environment, or, perhaps, more precisely, a new climate : the risks incurred by the imported animals will likewise be construed as the outcome of the more or less severe bodily disturbances set up in the course of the adaptation to the new climatic conditions.

There has been much discussion of recent years upon what effect changed climate in itself has upon the constitution. While general experience seems to be almost unanimous in declaring it to be something capable of affecting health to a most pronounced degree, it has not been possible by scientific investigation to determine the effects of the change with any degree of precision. The protagonists of residence in the tropics have adduced evidence purporting to show that children develop as sturdily in warm countries as they do in colder climates when every care is taken to exclude danger of disease from them during their growth ; the more precise experiments of physiologists have shown that the basal metabolism of residents of the tropics may be even higher than that of many people in temperate countries. On the other hand, there has been forthcoming some evidence to show that although the children of Europeans may develop bodily and intellectually at an even faster rate in warm countries than the average of their kind in Europe until they reach a fairly advanced stage of adolescence, they almost inevitably fall appreciably behind those brought up throughout in Europe when they reach the young adult and adult stages. It can scarcely be argued that the pigmentation of the skin of inhabitants of hot countries and their relatively lethargic temperaments must be the evolutionary products of more intensive sunlight and higher atmospheric temperature. A paradoxical phenomenon is observable, however, on comparison of some breeds of Indian cattle with those that preponderate at the present day in Northern Europe, for some of the best breeds of Indian cattle are remarkable for their agility and physical endurance, whereas some of the most favoured British breeds, for example, the

beef Shorthorn and Aberdeen Angus, are noted for their lethargy. These differences are explicable, in reality, for the most part, on the assumption that they are the outcome of artificial selective influences on the breeds, during many generations of so-called domestication.

It is again undoubtedly true that Europeans are more prone to sunstroke, or heat apoplexy, than are the residents of warm countries with pigmented skins. A very curious condition observed in many hot countries among imported cattle is a peculiar dermatitis which affects the unpigmented parts of the skin and is produced after the ingestion of quantities of certain foodstuffs, such as green clover, lucerne, or trefoil, or buckwheat. When a Holstein beast becomes affected in this way the white parts of its skin become covered with irritating sores, which are sharply limited to these parts and do not affect the coloured portions of the skin. It seems that a photo-sensitive substance absorbed with the foodstuffs is excreted through the skin and under the action of the strong direct rays of the sun is converted into something which produces the irritating effects upon the white patches.

For a period of two years (1922-1924) we carried out a series of experiments concurrently at Muktesar (altitude 7,500 feet) and at our branch laboratory on the plains, at Izatnagar, near Bareilly, to ascertain whether or not climatic conditions influenced the resistance of animals towards rinderpest. At intervals of three months throughout the two years, a certain initially potent brew of anti-rinderpest serum was tested simultaneously upon six bulls of pure hill breed at Muktesar, at dosages of 90, 60, and 30 c. c. per 600 lb. body weight (2 bulls each dose, with 2 bulls injected with virus alone as " controls ") ; simultaneously with each Muktesar test, a batch of exactly similar bulls was tested at Bareilly. The results indicated that cattle showed about the same resistance to infection, under the graded protective influence of the serum, whether during the cold weather they were subjected to test in the snow-bound conditions of Muktesar or to the mild concurrent conditions of the plains, and whether during the hot weather they were tested in the temperate conditions of Muktesar or in the heat of the plains. In fact, during the hot weather, the resistance displayed by the Bareilly animals seemed to be somewhat higher than that exhibited by the Muktesar animals ; this paradoxical result may have been attributable to the fact that at Muktesar the animals then under test were housed in substantial stone buildings, designed to protect against cold, and likely to develop a high and oppressive relative humidity in their interior during the warmer weather, whereas the animals at Bareilly were maintained in straw loose-built sheds, or *chuppers,* in which the air was more amenable to rapid interchange with the external atmospheric air.

The experience of very many years in the new large stock-raising countries, such as Argentina and South Africa, that endeavour to attain the largest measure of productivity by the maintenance of herds composed of the most reputable European breeds, has been that the progeny of the imported ancestors tend to fall off con-

siderably in stamina after a few generations, and that it is necessary to resuscitate the vitality of the stock by the infusion of freshly imported blood from time to time. Recent investigations carried out by the veterinary authorities in South Africa would appear to throw some light upon this problem of deterioration. Enquiries into the origin of a peculiar paralytic disease known as *lamziekte* affecting cattle during the drier seasons on certain areas of the veldt elicited the information that the cattle which succumbed to this disease had previously shown symptoms of a depraved appetite, or pica; in this condition, they exhibited a craving for chewing the bones of carcases which were strewn on the veldt and were discovered to be infected with a local soil organism of the *botulinus* type, that elaborated a powerful toxin in the carcases. It was further found that when the animals in the herds afflicted with pica were fed regularly with small daily quantities of bone-meal the craving for bones ceased and no further cases of *lamziekte* occurred. It has been communicated to us by veterinary officials that a similar type of affection occurs in certain localities in India. The further examinations of the South African authorities showed that the pica, curable by the administration of bone-meal, was attributable to the ingestion of forage plants found to have a particularly low phosphorous content, and that the low content of the plants in this element was brought about by relative deficiency of the soil in phosphates. Again, the daily feeding with bone-meal of herds affected anywhere with pica was found after some time to have a remarkable effect in improving bone formation and general stamina in the animals, with the result that physical deterioration did not take place.

In certain countries, veritable outbreaks of a peculiar bone disease known as osteomalacia take place among animals. Recent researches in Norway have shown that the condition is attributable again to a phosphorous deficiency in the soil (whilst the calcium content was quite normal), and that it can be prevented by feeding with materials such as bone-meal or foods, such as bran, rich in phosphates.

This information proves, at any rate, that in the case of grazing animals soil factors may have a significance no less worthy of study than those of the aerial environment. In fact, this information seems to be well-ingrained in the British breeder of livestock: a breed of sheep of excellent qualities in a certain locality fails utterly to come up to expectations when taken to another locality perhaps only about forty miles away; again, in spite of the excellence of certain breeds of cattle such as Shorthorns for dual purposes, it is remarkable that a locality like South Devon has retained its original breed for these purposes. One cannot help but think that this specific affinity of certain breeds evolved in certain localities is a function of their capacity for thriving on the locally grown fodder, which again is largely a function of the soil characteristics.

The foregoing somewhat cursory allusions to points of interest in general experience and to inferences of more exact observation are made merely to show our recognition of the possibility that simple physical or chemical factors may play at times an important part in the phenomenon of acclimatization. Briefly recapitulated,

they are concerned with the characteristics relating to climate—temperature, humidity and seasonal changes—and soil, and, largely through the interaction of these two factors, the local resources in fodder supplies. It is not our purpose to dilate further upon them in this short paper, but to proceed to analyse what we believe to be the main factor in acclimatization, at least in so far as this phenomenon refers to the survival of cattle imported into India. This factor, we have good reason to believe, is specific infectious disease, or, more precisely, parasitism. The term parasitism is believed to designate more accurately the factor we have in mind: all specific infectious disease is caused by parasitism, but parasitism is not invariably associated with manifest symptoms of disease.

We know quite well that certain diseases prevail in India that have been eradicated or are kept well under control among the livestock of Western countries, and, on the other hand, certain cattle scourges of the West are at present happily rare among the livestock of India.

The most notorious cattle disease of India is cattle plague, or rinderpest—the last serious outbreak of which was exterminated from Great Britain as far back as 1865-66 after costing the State over five million pounds sterling.* Cattle plague has surged in waves of periodic intensity among the cattle population of India, it seems, since time immemorial, so that the present-day breeds on the plains represent the progeny of an unlimited lineage that has survived attack. It has been computed, with a fair degree of accuracy, that some of the plains breeds are fifty times less susceptible to rinderpest than are the British breeds of cattle. Nevertheless, Indian cattle show considerable variation among themselves in susceptibility. The small hill breeds of the Himalayan foot hills are found to be about eighteen times more susceptible to the disease than are the least susceptible plains breeds. Again, some of the plains cattle may be six times as susceptible as the least susceptible animals. The technique of the serum-simultaneous inoculation has so far advanced in recent years, however, that there is no reason why the stock-owner should apprehend danger to his imported or cross-bred stock from this disease if he takes timely advantage of the services which the veterinary department can place at his disposal for conferring a durable immunity upon his animals by the method. The researches carried out at the Muktesar Institute and still in progress have enabled us to despatch the requisite virulent material to arrive in a fit state for employment in the method of inoculation in all parts of India. It is hoped that before long this

* This large expenditure was entailed as the outcome of the dilatory measures adopted in first dealing with it, when the Government, instead of paying heed to the advice of the expert veterinarians of the country, who pleaded for the immediate adoption of "stamping out" measures, consulted the opinions of eminent medical authorities, who foolishly advocated control by drug treatment. The object lesson of this costly outbreak, and the complete success that attended the adoption of the measures advocated by the veterinary authorities in suppressing at relatively negligible cost the only further outbreak that occurred, in 1877, led to the establishment in England of an efficient permanent veterinary department for the control of epizootic disease, which is now regulated by the Diseases of Animals Act, 1875, and later enactments. At the time of the 1865 outbreak, the disease also appeared in France, which was happily in possession of an organized veterinary department, the efforts of which eradicated the disease with very small loss.

inoculation can be performed with almost perfect safety even upon imported cattle, for the only real danger from it resides in the complications that may ensue from contamination of the virulent material employed with parasites other than those of rinderpest. This contamination, as will be explained later, is, as a rule, of no consequence when the material is used upon indigenous cattle.* This opinion is substantiated by the results achieved in the splendid pioneer work recently undertaken in Mysore State with the inoculation, wherein 49,244 animals have been inoculated according to the latest information received (14th February, 1927), with a mortality of 344 animals only (=0·69 per cent. mortality). This is the lowest mortality yet recorded in any country after the inoculation. (In Egypt, where the veterinary authorities had claimed an exceptionally low record of mortality with the method, there were inoculated during the years 1912-21, 514,452 animals, with 4,688 deaths =0·91 per cent. mortality.)

Methods are now available also, as the outcome of laboratory researches, for conferring sure protection against the other more notable diseases of India, hæmorrhagic septicæmia (or buffalo plague), blackquarter, and anthrax (which usually attacks indigenous cattle less severely than it does European cattle). The two last mentioned diseases are not peculiar to India, but are prevalent also in Western countries.

Foot-and-mouth disease is common and widespread among indigenous cattle in India, and the ill-effects caused by it are on the whole much less acute than are those commonly observed in European cattle. It has been reported that newly imported cattle suffer very severely in the scene of outbreaks that are relatively mild among the indigenous cattle.

It has been stated that certain cattle scourges of the West are now rare among cattle in India. The worst cattle scourges in the West, and particularly in Great Britain, at the present time are tuberculosis and contagious abortion. Bovine tuberculosis is of particular gravity on account of the potential danger it represents towards the human population; so far as direct economic losses are concerned, the British stock-owner is probably disconcerted more by contagious abortion. It has been estimated that about 30 per cent. of the cattle of Western Europe are affected with tuberculosis, often severely, and some time ago a distinguished authority maintained that there were probably not ten large herds in England which were not affected with the disease. In India, the figures forthcoming from examinations of carcases at certain slaughter-houses indicate that less than three per cent. of the cattle harboured visible lesions of tuberculosis, and in the affected animals the lesions were usually localized and not likely to have caused any serious bodily disturbances.† We now know that the tubercle germs of these Indian cattle are as

* Recent researches at Muktesar have enabled us to circumvent this complication of piroplasmosis arising in cattle following upon the accidental introduction of the piroplasms with the so-called virus used in the inoculation. This has been done by "fixing" the virus on goats, which do not harbour the piroplasms of cattle.

† Some very recent investigations carried out by Soparkar, however, have disclosed a very much higher incidence of infection in cattle (Lahore, Ferozepore), when minute search is made for tuberculous changes in the bodies of animals.

virulent as those of affected European cattle, and that many Indian cattle at least, are not markedly less susceptible to the disease than are European cattle. It seems that the main factor in limiting the spread is the common mode of life of Indian cattle, which may become affected, from the information we now have, in much the same manner as European cattle, when they live in similar conditions of domestication.

Again, with contagious abortion, it has been found that indigenous cattle living in typical Indian conditions in certain localities in the Punjab harbour this germ in the proportion of about ten per cent., but never actually abort from the infection. When cattle are maintained in conditions simulating those of Western dairy herds, as at some of the Government Military Dairies, the proportion of infection may rise to 50 per cent., and, of actual abortion, often repeated two or three times in individual animals, to 20 per cent.

It will therefore be seen that some of the worst scourges of the West are not absent from India and that they are potential sources of great danger when attempts are made to bring about livestock improvement by imitating the conditions of maintenance common in the West.

The more evident Oriental plagues are therefore amenable for the most part to control among imported cattle, by the artificial means now at our command, whilst the propagation of Western methods of domestication, for increased productivity, amongst the imported stock or the progeny obtained by crossing them with indigenous cattle, leads sooner or later to the appearance of the scourges most redoubted in the West. This belief is reflected in a statement made to me a few years ago by one of the Controllers of the Government Military Dairies, who said that since the application of the serum-simultaneous inoculation to the animals in his charge he had ceased to entertain much fear of rinderpest, but was most distressed with contagious abortion and Johne s disease.

During recent years we have accumulated a large mass of records at the Muktesar Institute, chiefly the results of the labours of Mr. Cooper and his assistants at the laboratory and the observations made by him and Mr. M. B. Menon in the field, which together with the rapidly growing corroborative testimony of workers in other countries, throw clear light on the precise nature of the parasitism which imported cattle have to suffer in the process of acclimatization to Indian conditions. This valuable knowledge has been obtained mainly in the course of careful examinations of animals reacting to the serum-simultaneous inoculation, in the laboratory and in the field, where not infrequently distressing complications have been observed to follow upon the inoculations. Although these complications have entailed sometimes the loss of valuable animals, they have been productive of information of fundamental value, which could not otherwise have been readily obtained. The observations will be described later in technical papers, but the facts of the situation can be briefly summarized at once for the benefit of the stock-owner.

(To be continued.)

THE CONSERVATION OF HUMUS IN INDIAN SOILS.

BY

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THE prime requirement of Indian arable soils is an adequate supply of organic matter or humus ; this statement no doubt partakes of the nature of a truism, but the writer's object in making it is to draw attention not only to certain considerations arising in connection therewith. but to the fact that there appears to have been a dangerous tendency in the past towards failure to recognize its importance.

The functions of humus in cultivated soils are numerous and most of them are well known, although some are still obscure. In India one of the most important is the modification of the relation between soil texture and the supplies of air and water to the plant ; a further one less fully understood has to do with the retention, in an accessible condition, of plant food for the crop. The effect of humus upon soil texture is not only its most important function but is one which cannot be performed by any other substitute ; it is not too much to say that the fertility of a soil depends primarily upon its content of organic matter and that when agriculturists refer to a soil as being " in good heart " they mean that it contains sufficient humus to secure fertility.

To increase the natural fertility of Indian soils we are taught by the experts of the Agricultural Department that it is necessary to practise thorough cultivat on, and that the old fashioned indigenous methods of the Indian cultivator must be improved upon by the use of more efficient implements such as those employed in Western countries. It is indeed easy to demonstrate in actual practice the increase in crop which can be obtained by this method, and as the capital outlay involved is small and the labour required is cheap, the recommendation to make use of increased tillage appears on the face of it a rational one. In 1919 the writer drew attention, in a paper[1] read before the Indian Science Congress in Bombay, to the dangers attending the introduction into India of high yielding varieties of crops and of intensive cultivation methods ; these were shown to lead inevitably to depletion of soil reserves in the absence of adequate provision for the maintenance of the latter. In the most recently published number of the Review of Agricultural Operations in India, 1925-26, by the Agricultural Adviser to the Government of India, this danger receives official recognition, both with regard to the effects of

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[1] *Agri. Jour. India*, XIV, Pt. 2.

improved varieties of crops and intensive cultivation. The remedy recommended, however, is the use of organic manures on account of their favourable influence on the texture of the soil, and a warning is given against the employment of artificial manures which have a tendency in the opposite direction. The object of this paper is to draw attention to the fact that although the use of organic manures has all the advantages claimed for it by the Agricultural Adviser to the Government of India, yet it is a mistaken policy merely to advocate the replacement of the depleted organic matter of the soil, without making any attempt to find out whether some less exhausting method of securing fertility than excessive cultivation cannot be adopted. This is especially the case where these organic manures are to be considered the principal sources of the necessary nitrogen supply.

It is no doubt necessary in India to make strenuous efforts to improve the primitive methods and implements of cultivation in general use, and this with one specific object amongst others, namely, the formation of a deeper layer of fertile soil in a condition of good tilth such as will conduce to the development of a deeper and more extensive root system. Improved cultivation of this type cannot do anything but good, but on the other hand there are mistaken methods of varying it in the direction of multiplication of ploughings which will inevitably lead eventually to disastrous results. Soil humus, far from being an imperishable substance, is rapidly attacked and destroyed by natural processes continually in operation. These processes are in part purely chemical and in part due to the activities of micro-organisms, but both of these classes of action are strongly activated by stirring the soil, which promotes aeration and therewith the numerous oxydizing processes, resulting partly in formation of carbon dioxide and partly of nitrates. The latter are removed from the soil either by rain-water or by the crop, the former, dissolved in the soil water, helps to bring into solution the mineral constituents necessary for plant growth. Mechanical stirring of the soil produces a further effect in the breaking-down of soil aggregates and particles and thus exposing fresh surfaces to oxydation and bacterial attack ; this result is again increased by the mutual attrition of particles which removes from their surfaces the accumulated protective layer or deposit, resembling rust, resulting from the oxidative or micro-biological processes above-mentioned.

The obvious effect of this intensive cultivation is an improvement in the immediate yield of the crop due to the increase in availability of the plant food present in the soil ; this however is obtained not only at the expense of the reserves of plant food in the soil as a whole, but more especially with reference to the destruction of its humus content. This use of the organic matter is a wasteful and unnecessary method of securing supplies of plant food, whether nitrogenous or phosphatic, for the reason that whereas no other soil constituent can fulfil the special physical functions of humus, it is perfectly easy to supply nitrogen, phosphates, and potash, under controlled conditions and in quantities which experiment can determine as suitable, in the form of fertilizers. The destruction of serious percentages of the

total humus content of the soil in order to secure a few pounds per acre of available nitrogen represents a method as uneconomic and wasteful as that involved in the use of an improperly balanced ration for cattle, in which the presence of an undue proportion of albuminoids involves the utilization of this expensive tissue-forming constituent as a source of heat and energy, in place of securing the latter by the combustion of carbohydrates and fat. In the same way intensive cultivation involves the diversion of an unduly large proportion of the soil humus from its proper physical function to the alternative, or rather additional, rôle of a supplier of plant food.

It is perhaps well to point out here that humus has an importance in the soil as a possible provider of organic nutrient or possibly stimulant substances to the plant, but on this point our information at present is scanty and uncertain.

It is of course to be remembered that an important function of organic matter in the soil is to provide food and energy for certain useful micro-organisms such as the nitrogen-fixers ; although cultivation by securing adequate aeration promotes this important action, yet excessive tillage by depleting the soil of its humus will eventually reduce it to insignificant proportions. The loss of humus is accompanied by a corresponding loss of soil nitrogen ; this result is drawn attention to by Russell[1] : " Directly ploughing and cultivation operations begin great losses of nitrogen set in " ; and again " The conditions for this decomposition " (involving evolution of gaseous nitrogen) " appear to be copious aeration such as is produced by cultivation and the presence of large quantities of easily decomposable organic matter. Now these are precisely the conditions of intense farming in old countries and of pioneer farming in new lands and the result is that the reserves of soil and manurial nitrogen are everywhere being depleted at an appalling rate."

H. A. Tempany, Superintendent of Agriculture, Leeward Islands, draws attention in his note dealing with fertility of soils in the Tropics, published in the " Transactions of the Third International Congress of Tropical Agriculture," to the rate of decay of organic matter in the soil : " It was found that in periods varying between six and twelve months the content of organic matter became reduced by amounts ranging between 12 and 30 per cent. of the total originally present." This rapid loss of humus occurred both in the laboratory and in the field. Numerous experiments carried out in the writer's laboratory at Pusa showed conclusively, both by measurement of carbon dioxide formation and of loss of nitrogen, that this very high rate of decomposition of organic matter is to be expected at the relatively high temperatures of Indian soils, and that it is greatly accelerated by aeration and mechanical disturbance.

Consideration of the above facts leads to the conclusion that great caution is necessary in making use of intensive cultivation as a means of securing an increase in fertility in Indian soils. We are faced with a problem of great complexity, any

[1] Russell, E. J. *Soil conditions and Plant Growth*, 5th Ed., pp. 246-247.

successful solution of which must depend upon securing much more accurate information than we at present possess as to soil conditions in this country. In the writer's opinion information should be sought along the following lines amongst others :—

(1) Experiments should be carried out to determine the conditions making for excessive rates of destruction of humus in various types of soil.

(2) Experiments should be made to determine the possibility of conserving reserves of humus by reducing the intensity of cultivation and at the same time supplying appropriate quantities of available plant food in the form of fertilizers.

With regard to (2) it is of interest to note that, when discussing this subject recently with the Chief Scientific Officer of the Indian Tea Association, this gentleman informed the writer that the suggestion above made was in entire accord with the most up-to-date policy of tea cultivation in Assam, as it combined reduction of labour with conservation of humus.

Here may be noted an important principle underlying the proper use of fertilizers in India, namely, that artificials should not be used as substitutes for organic manures but in conjunction with the latter ; this does not mean that they cannot be used alone on land which contains a sufficiency of organic matter, but that the cultivator must not take them as complete substitutes for the cowdung or oil-cake which he would ordinarily employ. On the other hand, it has already been proved that by judicious use of artificials in conjunction with cowdung the available supply of the latter can be made to cover a much greater area with economic effect, this being made possible by the use of sulphate of ammonia as a substitute, not for the whole usual application of cow manure, but for a third or perhaps a half of the latter ; in the experimental results which have recently come to the notice of the writer in India this partial substitution was followed by increases of crop of a substantial order and sufficient to give a highly satisfactory economic return. It is highly advisable, therefore, both in the interests of the conservation of humus and of that of the extension of the area under treatment with cowdung or other organic manures, that extensive experiments dealing with the possibilities of this partial substitution method should be carried out. It is perhaps unnecessary to say that such experiments should include investigation of the use of all kinds of artificial fertilizers, as, although the most obvious economic returns have been obtained with nitrogenous artificials, it is highly probable that still better results would follow the use of more complete applications, which would include minerals as well.

The value of humus and its functions in the soil are too well known to need further discussion here, but it may be well to draw attention to a particular point in connection with its value as a means of retaining in the surface soil a sufficiency of moisture for the needs of the crop, at a time when arid conditions render such supply necessary. In irrigation tracts there is the danger that the existence of a controlled water supply, independent to some extent of climatic conditions, may

lead to neglect of the conservation of the soil humus because of the less insistent necessity of observing this as a means of retaining soil moisture ; in districts where cold weather crops are grown under arid conditions any such neglect leads to obvious failure ; the land is then no longer " in good heart " and can only be brought back into this condition by prolonged operations involving green-manuring, heavy applications of organic manures, or fallowing. As this particular function of humus although of the greatest importance is by no means its only one of value, there is a distinct danger in irrigation tracts of a lowering of soil fertility as a result of failure to keep up supplies of organic matter in the soil, this being a consequence of failure to note the falling off in crop returns which would inevitably follow any serious reduction of humus content under arid conditions. Thus we may expect to find excessive cultivation practised in an irrigation area as compared with the smaller number of ploughings made use of in other districts. This will in time be followed inevitably by depletion of the organic matter content of the soil and a lowering of fertility, and probably by a corresponding reduction in the effectiveness of irrigation. In this connection, it may be well to bring to remembrance Leather's findings at Pusa which demonstrated the reduction in the quantity of water required to produce unit weight of dry matter in the crop, as a result of provision of suitable supplies of available plant food in the soil. This affords a further argument for the use of artificials in preference to securing available plant food by intensive cultivation, because of the comparative ease of providing such plant pabulum at the suitable period of growth by employment of the former. It may be pointed out here that the extensive use of fallowing practised in arid regions affords evidence of the recognition of the necessity for the up-keep of the humus content of the soil.

It is impossible to avoid partial destruction of the humus content of cultivated soil as a result of tillage operations necessary to secure a seed-bed and suitable tilth ; it is not however necessary to push this cultivation so far as to destroy large proportions of the organic matter of the soil in an ill-advised attempt to make the latter perform the dual functions of providing plant food as well as soil texture. This partial destruction must be provided against by the use of organic manures, but the quantities of the latter required to secure fertile soil conditions may be greatly reduced by the combined use of artificials ; the plant food supplied by the latter will thus reduce or altogether abolish the necessity of utilizing the soil humus as a means of providing supplies of nitrogen, phosphates, and potash.

It may be suggested that, in view of the limited supplies of cow manure and oil-cakes available in India, more strenuous efforts should be made to extend the use of green manures throughout the country ; much experimental work has been done on this subject, and in many parts of India the value of the method is well enough known to ensure its use, but the fact remains that over a large proportion of the arable area it is only occasionally practised. Several reasons exist for this failure to make use of such a valuable method of up-keep of soil fertility, one being the necessary loss of a crop and another the frequent failure to obtain any obvious

advantage from its use. It may be suggested that the methods of securing freedom from such failure which have been worked out in various districts should be given wider publicity and added to by further investigation ; it may be noted here that one of these, well authenticated in Bihar, is the use of superphosphate in conjunction with the burial of the green crop ; this is an instance of the high value of an artificial fertilizer in Indian agricultural practice and leads to the conclusion that there is no justification for the old established opinion that imported fertilizers can find no useful application for ryots' crops in this country. In any case it is important in the interests of the conservation of the soil humus that every effort should be made to introduce the practice of green-manuring wherever this is at present not in regular use, and that experiments should be carried out to ascertain the best methods of effecting this. It may be well to point out the advantages attaching to green-manuring as a method of up-keep of the soil humus as compared with the use of cow manure or oil-cake ; the first method involves no capital expenditure, which, even in the case of cow manure, is almost invariably required ; supplies of cowdung and oil-cake are not always available, nor would they ever be sufficient to meet the requirements of the whole country even if the former were not mostly consumed as fuel. The introduction of a green leguminous crop in the rotation not only serves as a partial fallow but helps to eradicate undesirable weeds. All these reasons in favour of the use of green-manuring are well known to officers of the Agricultural Department and are only mentioned here to emphasize the importance of the original equally well-recognized theorem at the beginning of this paper in view of the dangerous tendency to neglect the destructive effects of excessive cultivation upon the humus content of Indian soils.

Farmers in all countries hold certain opinions based upon experience and tradition rather than upon scientific knowledge or reasoning. Amongst such opinions no one holds a firmer or more universally agreed upon position than that which assigns to organic nitrogen a value considerably in advance of that with which its inorganic salts are credited. Experiments such as those carried out at Rothamsted on mangolds between 1876 and 1902 completely justify this attitude of mind so far as it applies to the substitution of inorganic for organic nitrogen, but also show, as Hall[1] points out, that the effects are due not to any intrinsic difference in the form of the nitrogen supplied but to the maintenance of the stock of humus in the soil associated with the use of organic nitrogenous manures. It is quite clear that to secure and maintain a condition of tilth in the seed-bed suitable for the early stages of growth of the seedling crop is of vital importance in India even more than in Europe, owing especially to the stringent conditions associated in this country with the supply of moisture to the young plant. This suitable condition of physical texture can only be secured in the presence of adequate supplies of soil humus, which intensive cultivation sooner or later will inevitably reduce below the requ'site level.

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[1] Hall, A. D. *Fertilizers and Manures*, p. 101.

The object of this paper therefore is not only to urge the necessity of realizing the prime importance of organic matter in Indian soils, but to point out that the very generally inadequate supplies of this constituent are in danger of depletion, as a result of the introduction and recommendation of cultivation methods which increase the rate of its oxidation and general consumption ; this method of obtaining increased fertility at the expense of the humus content of the soil is unsound inasmuch as it involves the utilization of this important constituent for a dual purpose, whereas part of this could be better fulfilled by the use of fertilizers, leaving the organic matter to carry out that function which it alone can perform by securing suitable mechanical texture in the soil. The practical interpretation of this argument lies in working out in the field suitable methods of combining the use of organic and inorganic manures, in such a way as to extend the existing supplies of the former over larger areas by their partial substitution by the latter. At the same time those fertilizers can be used to furnish part of the supplies of available plant food now being obtained by natural but wasteful processes, through the medium of cultivation and tillage.

AGRICULTURAL IMPLEMENTS SUITABLE FOR THE USE OF THE INDIAN CULTIVATOR.

BY

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(*Continued from Vol. XXII, Pt. IV, p. 290.*)

THE CULTIVATORS' REQUIREMENTS.

BEFORE discussing in detail implements to be included under this head, it will be as well to attempt to define the different kinds of implements in common use. To some readers the definitions may be objectionable in certain respects ; but all that is required is to explain, as a preliminary, what the writer means by the different terms that will be freely used in the following pages.

A plough is primarily an implement designed that it may in its passage through the soil turn over a strip 5″ to 9″ wide to a similar depth. The essence of the action of a plough is that it should turn over the strip of soil moved, thereby burying weeds, manure, etc., and bringing up from below and exposing to the air, soil from the bottom of the strip. To effect these, most ploughs are provided with a share which cuts the strip from the earth below, and a mould board which turns that strip in moving it to one side. In a disc plough both these processes are performed by the revolving disc.

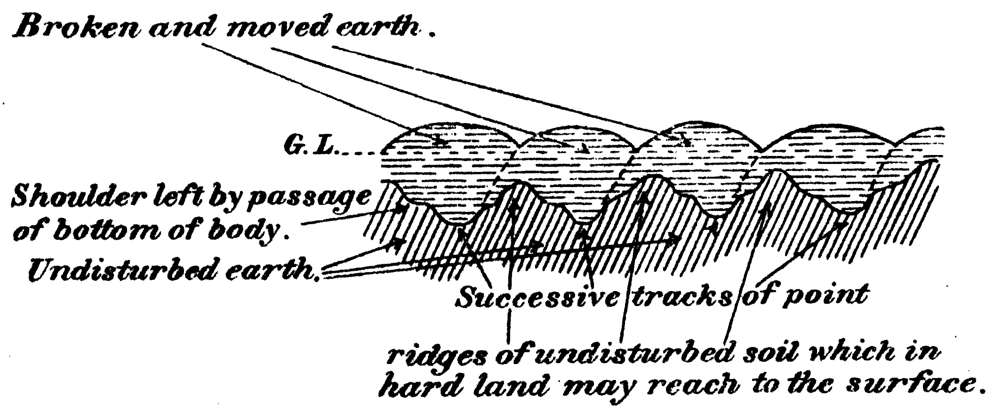
A ridge plough is, as its alternative name, double mould board plough, implies, a plough with 2 mould boards throwing earth to opposite sides of the central share, so that the strip of earth cut by the share is split by these mould boards, and part thrown to the right and part to the left, leaving an open furrow behind the share. Drawing this plough backwards and forwards along lines parallel to each other results in the land being thrown up into ridges and furrows.

A cultivator is an implement designed for stirring the soil, by dragging through it a number of points fastened in some way to a horizontal frame which is pulled over the surface. The tines of a cultivator are the points which actually pass through the soil and bear the brunt of the work, while the shanks are the connecting links between these points and the frame. Different shapes of tines do different kinds of work, but the essential function of a cultivator is that it shall stir up the soil without seriously disturbing the surface level, bring up from below a certain amount of earth, and displace from their root hold and lightly bury if they are small, or drag out and expose on the surface if they are large, grass and other weeds. The

country plough is a compromise between all three, and does the work of none satisfactorily. It is really a single-point cultivator of which the wooden body acts as rough double mould boards, and its action is mainly that of a cultivator, though the wedge shape of the body pushes the soil aside into imperfect ridges and furrows, and where the lines of travel are sufficiently close together the proximity of these ridges and furrows gives a rude effect of ploughing. But it cannot bury any but very small weeds, and it has to be used a large number of times in order to ensure that all the surface soil is moved.

Chas is a term very widely used in Bihar, I believe, for the passage through the soil of any implement, the points of which enter the soil and by which the soil is broken or stirred or moved. It is commonly applied to the work of the country plough, and is also used of ploughing with a mould board plough and of cultivations with any kind of cultivator, where these are used. Because the English terms ploughing, cultivating and ridging are not interchangeable, it is proposed to adopt the term *chas* in what follows.

As everyone knows, the Indian ryot performs most of the operations required in preparing and sowing his land with the country plough. The small iron point of this digs into the earth in a narrow furrow ; and the following, wedge-shaped, wooden body pushes aside to right and left the soil thus loosened. That pushed to the right is left as a crude furrow slice, only partly turned ; and as the tool comes round again the portion formerly pushed to the left is now pushed to the right to make a new slice some of the new earth dug up by the point being mixed with it. So the work goes on, each furrow entailing the digging up of a little new earth and the pushing to the right of some of this together with that previously moved to the left. A width of 6″ to 9″ is taken at each furrow, and when the field has been given one *chas*, though



Diagrammatic representation of the work of a country plough.

in soft land the surface may appear well worked, below the depth of working varies according as the point passed there or not. Where the land is hard, one can see on

the surface how little of the land is actually affected in each *chas*. A second *chas* is given at right angles to the first, and then a third and a fourth, and often more are necessary before all the soil to the depth of the point is moved. The extremely narrow point and the fact that there is only one, makes it necessary for man and cattle to traverse the field many times before they have moved all the soil to a depth of even four or five inches. But the work of the country plough at each *chas* is undoubtedly almost identical with that of a single point cultivator, and though the cultivator point does not push the soil aside to the same extent as the wedge body of the plough, the curved shape and width of a suitable tine cause the earth to be thrown forward and slightly sideways, sufficiently to have very considerable burying effect. Actually the work of a curved and fairly broad tined cultivator is at least as effective in bringing up soil from below and burying small weeds as that of a country plough. It is decidedly more so in getting the soil moved and stirred, because whereas the point of the country plough is 1 inch wide in a 6 to 9 inches furrow, in a 5-tined spring cultivator, for example, the external width is 24 inches, of which the points, 5 at 2 inches each, actually touch 10 inches, a proportion of 1 to $2\frac{1}{2}$ instead of 1 to 6. In many cultivators used for working between crops the tines are $2\frac{1}{2}$ inches and 3 inches wide, so out of a total width of 20 to 24 inches $12\frac{1}{2}$ to 15 inches are taken up by points. It is obvious that 1 *chas* with a tool like this is equal to 2, 3 or even 4 with the country plough for the purpose of moving, to a uniform depth, a layer of soil.

From the foregoing, we may, I think, safely conclude that the one implement the ryot really requires is a cultivator as defined above. For certain particular works for which he uses a *kodali*, a plough or a ridge plough would be a great asset. But primarily he needs a cultivator, and it will be found in actual practice that a cultivator will do 75 per cent. of the cultivation he attempts to carry out. A suitably designed cultivator will break land after harvest, stir it and so reduce it to a tilth in the course of the season, mix in with it short manure, and cover, efficiently, seed. Its advantages over a country plough in performing these operations are that the number of its points distributes the stirring effect more evenly over the width of land affected by its passage, so that it need not be used so many times to stir the soil as efficiently as required, and, secondly, as the friction is reduced to that entailed by the passage through the soil of a number of comparatively small suitably shaped points instead of one point and a large wooden wedge, more of these points can be used, and so the width of land effectively treated at each *chas* can be radically increased. In other words a cultivator will produce a tilth with about half the number of *chases* as would be required from a country plough, and at each *chas* it works a wider strip of land than does a country plough, and so gets over the same area of land in a shorter time. In fact a cultivator that can be drawn by any pair of bullocks such as draw a country plough, will do in 2 to 3 cultivations as effective tillage as is done by a country plough in 4 to 6, and in a given time will get over twice the area of land. So that to effect any given operation the amount

of labour required of man and beast is reduced fourfold. In addition, a cultivator, if suitably designed, can be used to cultivate land between growing crops provided these are sown in line, an operation which a country plough will not perform and which has to be done by a *kodali* or a *khurpi*. We may conclude therefore that the implement required primarily by the Indian ryot, and certainly by those too poor to buy more than one implement, is a cultivator. And that is the implement which, if it can be provided of the right design and at the right price, will sell literally by the crore.

There are certain operations such as the opening of a furrow sufficiently deep and clean-cut to plant cane or potatoes, and the putting up of ridges for drainage of such crops as cane, maize, cotton, etc., which, although they can be carried out after a fashion by a specially large bodied country plough, do in fact really need a properly designed ridge plough. Wherever cultivators have had the opportunity of using such a ridge plough for these works, their appreciation of it has been very evident : and there is no doubt that such a ridge plough would sell in very large numbers, particularly in those tracts where methods of cultivation are comparatively advanced.

There is considerable diversity of opinion as to whether the Indian cultivator really requires a plough, and doubt was thrown on this recently by so eminent an authority as Mr. A. Howard, Director, Institute of Plant Industry, Indore. While it is probably true that furrow inversion is not so often required in India as in the damper West, there are certain advantages of the process which seem very difficult of attainment by other means. Even in India it is often necessary to plough in comparatively long trashy manure, or green manure, and this can only be done effectively by a furrow inverting plough. Often for late monsoon sowings the only way of coping with the strong growth of grass and weeds produced by the early monsoon showers, is to plough them in deep, and sow on the clean furrow thus brought to the surface. This seems often the case in Bihar in the hot weather also. Actually in preparing a tilth for any crop, it is necessary to stir efficiently the whole layer of soil to a depth of 6 to 9 inches. A good ploughing will detach from the earth below, and actually shake up and move, all the soil to the required depth, at one operation ; whereas a country plough can only do it thoroughly in 4 to 6, while a cultivator requires at least 2, one in each direction. So that, with certain limitations as to its intelligent use on certain soils and when all soils are in certain conditions, there is, I think, no doubt that the pough has its place, and a very considerable place, in the economy of cultivation of Indian soils, and this statement is borne out by the interest displayed in these ploughs by very large numbers of Indian cultivators and the numbers of iron ploughs, partly or wholly unsuitable to the local conditions of work, that have been sold in the country. In Bihar there are large numbers of iron ploughs working daily, and I am continually astonished at the number of people round the Sepaya farm desiring to hire ploughs from us. They would buy with very little encouragement ; but I have so far refused all encourage-

ment in this direction owing to the unsuitability of the types at present available. I think we may agree therefore that where a really suitable cultivator will sell by crores, equally suitable ploughs, even if not required in such great numbers, will still sell by lacs.

(*To be continued.*)

A CROSS BETWEEN INDIAN AND AMERICAN COTTONS.*

BY

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It is well known that crosses between American and Indian cottons are extremely difficult to obtain. While the cottons of the old world cross with one another quite easily, and those of America are equally fertile among themselves, it has been usually considered that it is practically impossible, by any known method, to secure a cross between them. Recently Zaitzev[1] has claimed success in crossing American and Central Asian cottons, by removing the staminal column sheath of the flower and then pollinating the stigma. The hybrid, so produced, however, proved sterile.

The opportunity to make an attempt in this direction came to me when working at Dharwar. Here a pure strain of Kumpta cotton (*Gossypium herbaceum*) known as Dharwar No. 1, and of Dharwar-American (Upland) cotton, known as Gadag No. 1, isolated by Kottur, are maintained. Using these types as materials, and employing Gadag No. 1 (American cotton) as the male parent, attempts were made to obtain successful bolls by various methods of treatment of the female stigma before pollination.

The technique adopted was as follows. The flowers of Dharwar No. 1 (*Gossypium herbaceum*) cotton to be used as the female parent were all emasculated in the early morning before the bursting of the anthers. Where various solutions were employed these were painted on to the stigma with a brush about ten minutes before pollination, and were allowed to dry up completely before the pollination was carried out.

It may at once be stated that in every case where the pollen was twenty-four hours old, no fertilization resulted. Fresh pollen seems absolutely essential. Further, when the stigma was painted with distilled water or dew, complete failure resulted. But the following treatments *did* lead to the formation of bolls. In all cases the cross was counted successful if bolls developed and remained on the plant for thirty days after pollination :—

(*a*) Pollination without any treatment beyond emasculation, led to *one* successful boll out of 200 flowers pollinated. In this case the flower was pollinated with fresh pollen between 3 and 4-30 P.M.

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* The work recorded in this note was done by the author when research scholar of the Indian Central Cotton Committee at Dharwar, under the direction of Mr. G. L. Kottur, Cotton Breeder, Southern Maratha Country.

[1] Zaitzev. A hybrid between Asiatic and American cottons. *Bull. Appl. Bot. and Plant Breeding* (*Russian*), Vol. XIII, p. 117 (1922-23). See also *Agri. Jour. India*, XXII, Pts. 3 and 4.

(*b*) Pollination after removal of the sheath of the staminal column led to two successful bolls out of fifty flowers pollinated (4 per cent.).

(*c*) Pollination after painting the stigma with extract made from the stigma and petals of the male parent led to two successful bolls out of fifty flowers treated (4 per cent.).

(*d*) Pollination after painting the stigma with two per cent. cane sugar solution gave one successful boll out of fifty flowers treated (2 per cent.).

(*e*) Pollination after painting the stigma with cane sugar dissolved ($1\frac{1}{2}$ per cent.) in extract from the stigma of the male parent led to three successful bolls out of fifty flowers treated (6 per cent.).

(*f*) Pollination after painting the stigma with citric acid solution ($1\frac{1}{2}$ per cent.) gave *twelve* successful bolls out of 100 flowers tested (12 per cent.).

(*g*) Pollination after painting the stigma with a solution of 1 per cent. citric acid and 0·5 per cent. cane sugar solution gave *twenty* successful bolls out of 100 flowers tested when the operation was done at 4 P.M. (20 per cent.). and two successful bolls out of twenty-five flowers treated when the operation was done at 9-30 A.M. (8 per cent.).

The general result was, therefore, that a substantial proportion of successful fertilization was obtained only when the stigma to be fertilized was previously treated either with an extract of the stigma of the male parent, or with citric acid, or still better with citric acid mixed with a solution of cane sugar. The highest percentage of success was obtained in the last named case.

In order to achieve success in making this cross the following precautions appear to be necessary. In the first place cloudy and wet days must be avoided altogether. Then the solution applied to the stigma must be allowed to dry up completely before pollination is made. Further, *fresh* pollen must be used profusely. More success is likely to be obtained if the female parent plants are raised in pots where conditions can be carefully controlled. Pollination may be started from the commencement of flowering, but flowers appearing at the end of the season should be rejected for the purpose.

In following up the results so obtained, the author was handicapped by the presence of wilt in the field where the experiments were conducted, and all the plants, except one of those where the fertilization had been successful, were lost. The one remaining gave seed which was sown in the next (F_1) generation, when a very vigorous hybrid plant was obtained. This hybrid, from seed borne on a Dharwar No. 1 plant, had a large number of features characteristic of the American parent. The cotyledonary leaves were large, the stalk was long and red, and white spots were present exactly as in Gadag No. 1 cotton. The leaves had the tint (dark green) and the shape of the American parent, while they were extremely hairy, the types of hair most common with Gadag No. 1 predominating. In the matter of the form of the plant, that is to say, the node at which the lowest

primary fruiting branch arises, the cross again was like the American parent. The flower buds were large (as in Gadag No. 1) and the bracts were longer and broader than in either parent. In other flower characters the cross was closely similar to the American cotton, except that the flowers were pale yellow and the red eye in the flower, characteristic of Indian cotton, was present, though it was not as large as in Dharwar No. 1. The anthers were pale yellow, being intermediate between the deep yellow of the *herbaceum* parent and the white of the American. Pollen grains of the types characteristic of both parents were found. The young bolls which developed only to a very early stage, were similar to those in Gadag No. 1.

As already stated, one hybrid plant was raised in 1925-26 and grew with very great vigour, producing 532 flowers during the season, but not one single successful boll was obtained. This is in accordance with the experience of Zaitzev, but the cause of the failure is as yet quite unknown. The external part of the flowers did not show any defects or malformations, and there was proper development of pollen. The anthers appeared quite healthy and both the pollen grains and ovules did not show any obvious defects.

In order to test whether the pollen from the hybrid plants was sound or not, back crosses were made by using this pollen on flowers of both Dharwar No. 1 and Gadag No. 1. Both of these have been successful and the resulting seed as planted in 1926.

In conclusion, it may be stated that a technique has been described by which a pure strain of *Gossypium herbaceum* (Dharwar No. 1) as the female parent can be crossed with a pure strain of *Gossypium hirsutum* as the male parent. The most successful result has been achieved by treating the stigma prior to pollination with a dilute solution of cane sugar and citric acid. The plant obtained from the resulting seed was vigorous, and in it the characters of the American parent were highly predominant. It produced abundant flowers, none of which, however, gave bolls and hence no seed was produced. There the matter remains for the present.

KUMRI CULTIVATION.

BY

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I

WITHIN forests and other areas recently opened up, the mode of cultivation followed by the hill-tribes, jungle-folk and races of inferior culture is predatory and entirely nomadic in character. This primitive cultivation is at the present day prevalent all over India, in Burma, Assam, the Central Provinces, Central India, and on the Western Ghats. An endeavour is made here to explain the economics of this primitive agriculture, and to state the problems that it raises. An attempt is also made to suggest the main lines of improvement. As it presents the same features and problems all over India, an intensive study confined to one definite region would be of advantage. This paper is based on a study of the practices followed by the hill-tribes of the Western Ghats.

KUMRI PROPER AND HAKKAL.

As in all countries where there is a great extent of forest waste, crops are raised in the *malnad* taluks on the west coast of Southern India by migratory or other primitive forms of agriculture. They are practised in this part of India mainly by the jungle-folk, especially by the Maratha Arés or Kunbis.

The methods adopted by the Kunbis are simple. Trees are felled on a forest site and set fire to. The clearings thus made are singularly fertile from the abundance of the ash manure and vegetable moulds. This kind of cultivation takes one of two forms : the *Kumri* proper and the *Hakkal*. The Kumri lands are those clearings in which the cultivation carried on is temporary and migratory. In the case of the Hakkal, the grip of man on the clearings is never relaxed when once the soil is rescued from forest growth. This happens when valleys are brought under cultivation where the inroads of wild growth are not persistent and aggressive. In such lands rice is sometimes grown.

TECHNIQUE OF KUMRI AND HAKKAL CULTIVATION.

The technique of the Kumri tillage is by no means elaborate. Soon after the rains a hillside on a forest area is generally chosen, on the slopes of which a space is cleared at the end of the year. The trees that have been felled are left to dry

till the following summer, March or April. During November, December and January, the patch of hillside to be used is cleared of brushwood and the branches of large trees are lopped and pollarded. The loppings are left till March or April, when the sun and the easterly winds have made them as dry as tinder. The Kunbi now decides to set fire to them. When lighted the timber and brushwood burn fiercely, and the soil is baked from three to six inches below the soil. The ground is left untouched by implements of any kind, and the rains are eagerly looked for. With the onset of the first rains, the seeds are sown. The only further operations are fencing and weeding. When the plants begin to sprout, a strong fence of fallen trees or a wattled wedge is raised round the clearing to keep off the wild beasts. Though no elaborate treatment is needed, constant watching and constant weeding are exacted of the Kumri labourer. The ripening crop offers a great temptation to the denizens of the forest, and for a month before harvest, the crop is watched at night by a person on a raised platform. The crop is reaped between October and December. A smaller one *in supa* is taken off the ground in the second year, after which the spot is deserted until the jungle is sufficiently high to tempt the Kunbi cutter to renew the process.

This nomadic type is to be differentiated from the permanent Hakkal cultivation in that the treatment and the operations involved in the latter are more elaborate. It is carried on, as mentioned above, in valleys, and by clearing brushwood or scrub jungle or grass. The men burn them when they are dry. The crops and the methods pursued are the same as in the Kumri but more tillage is required. When there is no brushwood, burnt earth or ash manure is brought and spread on the plot.

With the increase of population, rise in prices and advance in knowledge, Hakkal cultivation is not so completely left to the hill-tribes. Near the coast, lands hitherto left to waste or only occasionally resorted to are now being taken up for permanent cultivation.

The processes involved in Hakkal cultivation are more improved than those in the Kumri. The male members after burning the bushes leave the remaining portion of the work to the women. When the rains commence, they dig up the ground with a small, sharp-edged bamboo hoe to the depth of three inches. A woman in one day can hoe about ten cubits square, and on the next can sow it. The sowing season lasts about two months ; so that the quantity sown in a year by a woman may be estimated at somewhat less than the sixth part of an acre. The custom, however, is for all people of one village to work one day on one family's ground, and the next at another's in regular succession. The women perform also the whole harvesting.

Crops and their yields.

The variety of crops raised in both the Kumri and the Hakkal lands is the same except that rice is, sometimes, grown in the latter. The principal crops are *dhal* (pigeon pea) and cotton in small quantities; castor and gingelly ; various cucurbi-

taceous plants, *shamay* (*Panicum miliare*), *ragi* (*Cynosurus corocanus*), here and there dropping in a seed of the leguminous type ; mustard, maize, horsegram, turmeric, chillies, the last being the most paying, but at the same time involving great labour and considerable outlay. Grains are sown separately, but seeds of the cucurbitaceous fruits are mixed with farinaceous crops.

The returns in the first year are said to be prodigious, but may be estimated at least double what can be raised under ordinary methods of cultivation. That this is nothing extraordinary will be evident when the nature of the forest site is considered. The virgin soil wonderfully rich, rendered still further fertile by the presence of the ash manure and the abundance of humus always to be found in forests of any considerable age, yields for the small quantity of seeds sown a bountiful harvest. That these primitive cultivators are not mistaken in their instincts is clear from the fact that some of the finest coffee estates worked with European skill and methods in the Mysore State have been formed in the Kumri lands which have been recognized to possess a rich deposit of decayed vegetable mould that has not been exposed to atmospheric influence and hence to contain an almost inexhaustible store of organic and inorganic constituents available as food for the coffee plant.

ECONOMIC CHARACTER OF KUMRI TILLAGE.

So far attention has been mainly directed to the descriptive side of the Kumri cultivation. We shall now proceed to consider its economic character and consequences.

The most important feature about the Kumri cultivation is that little capital or skill is called for on the part of those engaged in it. No great outlay is needed ; nor the initial preparatory work, nor the highly elaborate machinery that characterize any industry in modern times. Two instruments, one for clearing, the other for hoeing, complete the Kunbi's outfit. With these he no more scratches the surface of the soil than it yields him a bountiful harvest—the yield is twice what is obtained under the normal modes of cultivation. So Kumri, when considered as a business proposition, fulfils the two conditions of the ideal aimed at by all entrepreneurs—maximum yield and min mum cost. All is well and sound thus far, and the Kumri venture offers a tempting prospect.

The main objection levelled against this nomadic form of agriculture comes from the point of view of forestry. From the very nature of the Kumri cutter's operations, it is evident that they involve an enormous destruction of forests and a great waste of timber. The proper conservation of forests has come to be realized to constitute a national problem of the first magnitude, and a matter of great concern to all countries. Besides their apparent advantages of providing supplies of timber and revenue to the State, their indirect influence is so great that it is well to digress a little on its nature and extent.

From the point of view of agriculture in general, which gives employment to 77 per cent. of our population, forests have conferred an untold benefit on the country. Throughout Dr. Voelcker's memorable report, the reader is impressed time and again with the utmost importance of adding to the existing forests by creating new fuel and fodder reserves on waste lands. More directly, the forests increase the fertility of the soil in which they grow. Trees are capable of making rich vegetable moulds from mineral soils. Forests have a marked effect on the climate and on the maintenance of water supply. They form, in the words of Mr. Eardley-Wilmot, "the headworks of nature's irrigation scheme in India ; and if these were injured or destroyed, the advantages of a regular water supply may be replaced by the tempestuous action of sudden floods, until such time as man with the aid of costly appliances intervenes to restore the equilibrium."[1] Perhaps the greatest assets of forests in India are to be found in checking erosion and preventing the good soil from being washed into the rivers and carried into the sea. The careless destruction of forests on mountain slopes brings into operation such great forces of erosion and denudation, resulting in landslips, tremendous floods, silting and destruction of fertile valley land that man is rendered helpless. From the operation of these forces even mighty empires such as Babylon are obliterated and whole populations running into millions of people, as in China, rendered homeless and destitute.*

It was the force of these arguments that brought about the interference of the State with the operations of the Kumri cutters. Their propensities may be sterilized at one stroke by administrative prohibition, but such a step is open to objection on other grounds. What these grounds are, how they are to be met, and the lines on which State regulation ought to proceed, we shall consider in the next part.

II

ECONOMICS OF THE MALNAD TRACT.

Administrative control and solution of problems of practical economics postulate not merely a theoretical grasp of the *pros* and *cons*, but a thorough appreciation of the local peculiarities, and of the nature of the relations developed between capital, labour and enterprise in that region. The history of how the Kumri problem was satisfactorily solved in the Mysore State offers an interesting instance of the manner

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[1] *Imperial Gazetteer of India*, Vol. III.

* See Sherfesse, "The Industrial and Commercial Importance of Forestry in China," *Chinese Social and Political Science Review*, September 1916. Cf. "In China deeply gullied plateaus, guttered hill-sides, choked water-courses, silted-up bridges, sterilized bottom lands, bankless wandering rivers, dyked torrents that have built up their beds-till they meander at the level of the tree-tops, and mountain brooks as thick as pea-soup testify to the changes wrought when once the reckless axe has let loose the force of running water to resculpture the landscape. From the once wooded hills opposite Hongkong the soil has been washed away till the country is nothing but granite boulders. North of the Gulf of Tonkin, not a tree is to be seen and the surviving balks between the fields show that areas once cultivated have become waste. Erosion stripped the earth down to the clay and the land had to be abandoned. One hears of districts, once populous, in which the mountains are dry, grey skeletons, the rich bottom lands lie smothered under silt, and there is now one family to four square miles." Ross, quoted in Dr. Radhakamal Mookerji's *Rural Economy of India*, Longmans, 1926, pp. 143-4.

in which similar problems have to be attacked. That experience suggests that unless great care is exercised, the fiat issued by administrative authority might bring a train of evils that may ultimately recoil on its own head. The lesson was bought there at a price ; a brief summary of the problem as it appeared in Mysore and the way by which a solution was reached cannot fail to be of interest to those who have to tackle similar difficulties elsewhere in India.

Kumri cultivation* was extensively practised in the *malnad* tracts of Mysore, especially in the Nagar and the Sagar Taluks of Shimoga till 1847. In that year the Government realized that this primitive agriculture was ruinous to forest growth and was economically objectionable. On these grounds the Kumri cultivation was prohibited. The direct effect of this measure was instantaneously felt by the cultivators. They depended for their means of subsistence solely on the Kumri lands. As the means were withheld, they emigrated in large numbers to the adjacent regions which were less inhospitable to them, where their operations would be tolerated. It is well to remember at this stage that the *malnad* tracts were most inaccessible. The dense forests and the malarial climate had kept away human exploitation. The only people who inhabited them were the hill-tribes whose operations, so long as they could not overtake the recuperative powers of the forests, were good enough. Further, the exploitation, of these regions, itself depended entirely upon the availability of the hill-tribes who alone were acclimatized enough to withstand the rigours of the trying climate. These Kumri tribes in their spare-time labours had effected in course of time a remarkable transformation of portions of the *malnad* into beautiful areca gardens. The garden cultivation would not have been but for the existence of these people.

The prohibition of the Kumri, as we pointed out, stimulated a wholesale emigration of the Mahratta Kunbis to other places, chiefly to North Canara. This was tantamount to dealing a mortal blow on the garden cultivation of the Kumri tracts. It appeared as if the State acted on the principle that the ravages of a hurricane from the west might be swiftly repaired by a tornado from the east. The presence of the Kumri labourer appeared to be essential and pernicious at the same time.

Equally serious were the other evils. The local ryots made bitter complaints that the wild animals were on the increase, and that the forests encroached upon the village lands and the cultivation. In 1869, it was reported that " the evils which have resulted from stopping Kumri are the increase of wild animals, and the consequent destruction to the crops of the land under regular cultivation ; " and " the loss of the Mahrattas who lived by Kumri who were of great assistance to the Wargdars. The latter is an evil yearly felt with greater intensity." Mr. Bowring, the Commissioner in Mysore, was no less emphatic in his condemnation of the stoppage of the Kumri. He wrote to the Government of India in the same year : " Hundreds and hundreds of acres are to be seen lying fallow in these frontier taluks

*In this part the term *Kumri* is used in its wider sense.

owing to the want of labour............ The means of the Wargdars have been much straitened, the aid which they procured from the neighbouring Mahrattas and others who cultivated their holdings, having been not only remunerative to them, but useful in a variety of ways." Two years later, Captain van Someran, the Conservator of Forests in Mysore, stated that "Tarèkulli and Gensinakulli, Numbers 5 and 6, were entirely desolate, and the gardens at Kadakodu (No. 4), were all but abandoned. At Hollapura one of the largest villages in the locality, the gardens, though better than at the spots just mentioned, were much in want of careful looking after. At Kulurmanè, the gardens were surrounded with old Kumri covered with small dense growth, and the owners complained bitterly of the order prohibiting Kumri." He said further that "the stoppage of Kumri cultivation had largely reduced the population of the country, that paddy fields and arecanut gardens had all suffered from want of sufficient labour ;" and later on that "the chief grievance is undoubtedly the loss of labour." In 1879, the same complaints were couched in even stronger language : "The gardens are thickly hemmed in by forests in which the spoors of beasts of prey are neither few nor far between...... large flights of these insects (*Bachè hula*) come from the adjoining jungles and on whatever crop they settle, it is destroyed in the same manner as Supari."

Convinced of the reasonableness of these representations, the Government of India (Mysore was then under the Commission) sanctioned, in 1869, the revival of Kumri under certain conditions, the most important of which was that the area assigned for the purpose should not exceed the total area under other cultivation.

These orders do not seem to have been given effect to and the whole question was shelved till 1885, when again it was reopened upon continued representations. The importance of preserving reserved trees and trees of minor forest produce, and the need for the introduction of valuable species, such as teak and sandal, in the Kumried areas engaged the attention of the Government at first. With these safeguards a scheme was drawn up and brought into force. When once the restrictions on the Kumri were relaxed, the Kumri operations were pursued with full vigour. The efforts made to preserve the reserved and other trees, and to restock the areas with valuable species failed. Gradually the other restrictions as well were ignored. The net result of the revival was evident. Valuable forest tracts were laid low by the axe of the Kumri cutter, and reduced to ashes. Very often no permission was sought for, and the cultivator took any portion that appeared to him most suitable for his purpose. "During my frequent tours in the Nagar and the Sagar Taluks," wrote the Conservator of Forests in Mysore in 1907, "I have traversed the whole of the Kumri tract extending from Kavaledrug in the south to the Jof Falls in the north..............and have been greatly struck by the destruction and loss of forest wealth caused by these men......Nagar Taluk has not suffered so much as Sagar. In the latter compact blocks of virgin forest of any appreciable extent are rarely met with, and the whole area forms a congeries of low bare hills, scantily stocked with belts of evergreen trees along streams."

"Les forêts précèdent les peuples, les déserts les suivront," wrote a great French forester.

The wholesale destruction of the forests left but one alternative to be adopted: to preserve what little remained and to restore the original conditions by rigid conservancy and protection. All large areas were therefore proposed for reservation. But the problem was not thus to be easily solved, something had to be done with the Kumri cultivator. He created a difficult economic problem. In the national interests, forests had to be protected from his depredations. But without access to the forests, he and his fellows left the locality for regions of less stringent laws. His habitat is the *malnad* tracts which are sparsely peopled, and only hill-tribes such as those to whom he belongs are physically immunized enough to inhabit them. It is in the economic interests of every country to exploit and effectively utilize the resources of every part of its territory. Further, the remoteness of the *malnad* from markets, and the inaccessibility to it were factors enough for the more progressive elements of the country to leave it unutilized. Regions like the Kumri areas can only be successfully worked through the agency of these hill-tribes. Their existence in that part of the country induced driblets of capital and enterprise to flow into it, which would not have moved in that direction but for the possibility of this labour, though primitive, being available. If the Government showed a disposition to tighten the forest laws, these tribes threatened the whole area with depopulation. The farmers and owners of the rice and areca plantations depended entirely on them for their labour, and if the labour emigrated, they too would have to follow suit. Prohibition of Kumri in 1849, as we have seen, actually led to the desertion of these tribes and to the emigration of enterprise which had based its hopes on the former.

A sober consideration of these facts led to the conclusion that there was but one remedy left. The Kumri cultivator has to be induced to remain in spite of the prohibition, and to wean him from his Kumri propensities and by persuading him to take to regular cultivation. This attitude was the right one and directed greater attention towards the Kumri labourer himself. His demands were not extravagant. He was satisfied with the minimum area that would support him and his family, which was about two acres for a family of five souls. His prime necessity is his Kumri land, and in spite of settling down with wet cultivation he must have it, for without his *ragi* and *savè* he cannot live. During the first year of the clear fellings, the Kunbi grows his *ragi* and in the second his *savè*. Thus each plot is generally worked for two years in succession and left fallow. He has now to be encouraged to conquer the temptation of the Kumri.

COLONIZATION SCHEME.

The Mysore Government met this problem, in 1908, by trying Kumri cultivation as an experimental measure on a limited scale with the special object of offering the tribes a strong inducement to cultivate assessed waste lands, and enabling the work-

men themselves to realize the benefits of the more permanent form of cultivation. The proposal was that "each Mahratta Kunbi be allowed one acre of land for Kumri every third year on the distinct understanding that he is to take up at the same time, a minimum of three acres of paddy land which he may be allowed to hold rent-free for three years." As there was a very large area of assessed and unoccupied waste in the Kumri tract, and as the agricultural population there had greatly decreased, the reclamation of these waste lands could, therefore, proceed only with the introduction of colonists. One could not be sure whether the maidan or the down ghat ryots could be induced to settle down in these comparatively inhospitable regions. "But the Mahratta Kunbi is already there and all that is required to make him an agriculturist is to restrict the area under Kumri and to afford him means to start as a regular cultivator."

It was realized that if left to himself, the Mahratta Kunbi would never be able to provide himself with the requisite agricultural stock, unless, of course, he chose to become the lifelong slave of the rich *patel* or the *shanbogh*. But the Kunbi likes to be independent; indeed, a few members of the tribe have here and there taken up land on their own account. Government help was therefore indispensable in persuading the greater part of the Kunbis to settle down as regular cultivators. To test the soundness of this proposal, about fifty men were selected, and a pair of bullocks and five rupees worth of grain supplied to each of them under the conditions specified. The desirability of protecting them from creditors and moneylenders was also understood. It was recognized that a novel scheme like this was bound to fail unless sympathetically watched.

Within a few years of the starting of this scheme signs of its success were in evidence. In five years the progress was encouraging as may be seen from the following table of the quinquennial survey of 1907-08 to 1911-12.

Year	Area of wet land granted		Area kumried		No. of families settled	No. of working hands
	Acres	Guntas	Acres	Guntas		
1907-1908	57	27	..	..	6	70
1908-1909	24	5	13	1	6	17
1909-1910	55	19	37	..	22	68
1910-1911	(a) 71	12	..	..	8	54
1911-1912	101	27	69	..	28	92
TOTAL	304	10	119	1	(b)90	301

(a) Only 57 acres and 24 guntas were given out to the fresh settlers and the rest to previous year's settlers.

(b) Includes two families struck off the account.

The advantages of these concessions have come to be gradually appreciated by the community. There has been since the inception of the scheme a strong movement among them to adopt a settled life under the favourable conditions introduced by the scheme. It is advantageous at this stage to review the sympathetic and helpful policy of th Government of Mysore towards the Kumri tribes. The most important of the concessions granted to them were : Each family was to be given one acre of forest lands for Kumri cultivation every third year, on the understanding that he takes up a minimum of three acres of paddy lands to be held rent-free for three years, but later extended to five years, and the free grant of a pair of bullocks (Rs. 50) and five rupees worth of seed grain. In February 1914, the Government offered further concessions to each family settling down. They were (1) a money grant of Rs. 20 during the first year of settlement ; (2) a sum of Rs. 10 for the expenses of journey ; (3) a grant of two acres of forest land for Kumri cultivation instead of one acre.

In June 1915, it was found that the grant for seed grains was insufficient and was raised from Rs. 5 to Rs. 10 ; and that for bullocks from Rs. 50 to Rs. 60. A loan was also given, not exceeding Rs. 30 to each family for discharging old debts. The continuance of the scheme is being guaranteed from time to time, and the annual budget allotments on the same was increased from Rs. 1,000 in the year of its inception to Rs. 5,000 in 1912-13.

As a result of these measures, there were by the end of June 1919, 256 families with a population of 1,231, living in 26 new colonies. Of these 112 families had completed the concession period of five years during which they held rent-free lands measuring 371 acres and assessed at Rs. 965. The progress of the scheme from 1907-08 to 1918-19 is indicated in the table given below.

Table indicating the particulars of families settled and other details.

Year	No. of families settled	No. of working hands	Area of waste lands taken up		Allotment	Expenditure
			Acres	Guntas	Rs.	Rs.
1907-08	16	70	57	27	1,000	217
1908-09	6	17	24	5	1,500	758
1909-10	22	68	69	10	600	816
1910-11	18	54	71	22	2,500	1,758
1911-12	28	92	103	3	3,000	2,030
1912-13	34	99	80	4	5,000	2,987
1913-14	82	229	264	1	5,000	5,000
1914-15	13	34	48	29	5,000	5,205
1915-16	26	76	83	10	5,000	3,201
1916-17	21	60	65	10	5,000	3,403
1917-18	8	20	26	10	5,000	1,723
1918-19	16	45	53	3	5,000	1,528

With the steady growth, in numbers, of these colonists the Government has been facing their growing problems. The need for the construction of wells, dispensaries, elementary schools, has been recognized and fairly met. Facilities have also been given for taking up useful spare-time occupation such as mat-making and rattan work.

This beneficent work of the State authorities is still going on. In 1926, for instance, 8 new families consisting of 30 members were added to the number of settlers, which has mounted up to 1,379 on June 30, 1926. The community is developing cottage industries, and the progress as regards rattan work has been achieved to a remarkable degree. A trained itinerant teacher and provision of scholarships for the boys learning improved methods of work are among the wisest acts of the Government. The more enterprising members of the colonists have been encouraged to form themselves into a co-operative society, which commands a strength of over 200. The State has gone further. It contemplates offering assistance to the settlers even in the matter of maintaining by careful selection a due proportion of males and females. This problem is engaging its attention at present as the males are found to outnumber the females.

DISTRIBUTION OF SEED ON SAWAII IN THE CENTRAL CIRCLE OF THE UNITED PROVINCES.

BY

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PRIOR to 1922 the system of wheat distribution in the Central Circle of the United Provinces had been essentially on a cash basis ; that is, seed was given out to cultivators and zemindars at sowing time and was paid for then, or the price was recovered after the harvesting of the crop. The latter procedure, however, resulted sometimes in a certain number of bad debts. Stocks of wheat were kept up by growing seed on Government farms and by purchase of seed at harvest time from selected cultivators who had grown their crops under departmental supervision. This system worked admirably when economic conditions and prices were fairly stable, no loss being caused to Government, as the price of wheat at sowing time was invariably higher than the price at harvest time.

In the years immediately following the close of the war this trend of prices did not obtain, and in some cases the harvest price of wheat was higher than the price at sowing time, losses consequently occurring to the seed distribution advances, when seed was purchased at harvest time and resold at sowing time. Owing to the insistent demand for economy necessitating the running of these advances without loss, the whole question was reviewed by the Director of Agriculture, and after a detailed enquiry and an examination of all the factors affecting seed distribution it was decided in 1922 to institute the method of wheat distribution on *sawaii*, and as that system has now worked satisfactorily for several years, it may therefore prove of interest to outline briefly the method adopted.

The system consists essentially in payment in kind, for the seed given out, rather than in cash. Thus for every maund of wheat given out from the seed stores at sowing time $1\frac{1}{4}$ maunds of wheat is recovered at harvest time. This rate of interest in force, *i.e.*, 25 per cent., is not in reality as high as it appears, since in most normal years the difference in the price of wheat at harvest and sowing time is such that very rarely is $1\frac{1}{2}$ maunds of wheat at harvest time worth more than 1 maund of wheat at sowing time. These advances of seed are all made on a standard agreement (Appendix A) which can be used for any variety of seed and which it will be seen embodies certain safeguards. A system of accounts, standardized for use in conjunction with *sawaii* seed distribution, has been put into practice throughout the province, and has been found satisfactory and simple to work.

The advantage of this system of distribution is that it is particularly acceptable to the small cultivator, who is not in a position to buy seed for cash. It encourages him to come forward for good departmental seed instead of relying on inferior seed obtained from other sources at a higher rate of interest. It has also been found easier in practice to realize the dues from small cultivators at harvest time in kind than in cash, and any loss to Government due to fluctuations of grain prices is obviated. Ordinary sales for cash, which still form the bulk of seed distribution work, are now practically confined to dealings with the large zemindars, District Boards, Co-operative Societies and Court of Wards Estates.

The criticism has more than once been brought against this system that if it is carried on for any length of time it is bound to result in the quality of the stocks of seed deteriorating, as the seed returned to the seed stores at harvest time will not, as a general rule, be so pure or of such superior quality as that which was given out. It is undoubtedly of the utmost importance that these seed stocks should remain pure and of good quality, otherwise all the efforts being made to introduce improved seed are negatived.

To guard against this, clause 3 of the bond (Appendix A) empowers assistants in charge of seed stores, who have strict orders on the subject, to refuse any seed that they consider of inferior quality, and quality is also maintained by the assistants only distributing seed of known purity on *sawaii* to cultivators who can be relied upon to grow a good crop and keep it pure. These assistants visit before harvest the fields of those cultivators who have taken seed and rogue out any plants that are not true to type. When any part of the stock at a departmental seed store is judged to have deteriorated in quality it is sold off in the bazaar, and the amount is made up by the importation of botanically pure seed grown on Government farms in the Circle, and when necessary stocks are also made up by purchase of seed from the fields of selected cultivators or from larger farmers who have received a grant-in-aid, and whose crops have been grown under departmental supervision.

During the last two years the latter method of augmenting the supply of pure improved seed available for distribution on *sawaii* has been instituted in the United Provinces. This takes the form of grants-in-aid to the owners of approved private farms on consideration of the grantees undertaking to grow under departmental supervision and sell to the department at market rates over a series of years a certain quantity of improved wheat seed.

The grant is only given after thorough investigation into the condition of the applicant who has to enter into a standard form of agreement (Appendix B).

It is anticipated that this method of utilizing private farms, besides improving the general standard of cultivation, will make available to the department a large reserve of seed of undoubted purity, produced more cheaply than on Government farms, which can be drawn on, where necessary, for distribution on *sawaii*.

Up to the end of the financial year 1927 grants-in-aid for the development of private farms on these lines had been made in twenty-two cases and for a total amount

of Rs. 41,000. The owners have contracted to grow under departmental supervision and sell to the department at market rates 18,650 maunds of Pusa wheat within the next 5 years. This amounts in practice to a premium of Rs. 2-3 per maund for the production of pure wheat seed.

This system of seed distribution on *sawaii* would appear to be applicable to any crop, but has not, as far as I am aware, been carried out except in the case of wheat and gram. It has also been found suitable for Court of Wards estates and Co-operative Societies who carry on seed distribution work, and several of these are now taking it up as a regular branch of their activities.

The amounts of wheat seed distributed on *sawaii* during the past five years in the Central Circle are as follows :—

	Md.
1922	6,306
1923	7,390
1924	8,497
*1925	6,465
*1926	7,703

* Excluding Bundelkhand Districts which are now constituted as a separate Circle.

It will be seen from these figures that there has been a steady rise in the amount of seed dealt with on this system.

APPENDIX A.

Translation of vernacular agreement.

We the zemindars and cultivators named below beg to submit our application in accordance with Act XII of 1884 for certain quantities of seeds as noted against our respective names, or whatever the Deputy Director of Agriculture is pleased to grant us for sowing purposes from the ———————— Seed Depôt and we promise to hold ourselves responsible jointly and severally to pay off the principal together with *sawaii* interest and to observe the conditions mentioned on the reverse of the application which we have clearly understood.

1. Serial No.
2. Name of the applicant together with father's name, caste and residence.
3. Status of the applicant, cultivator or zemindar.
4. Total area under cultivation.
5. Rent or revenue.
6. Kind of grain.
7. Quantity of grain required.
8. Signature of applicant.
9. Quantity of grain issued.
10. Signature of the issuing officer.
11. Remarks.

Attesting signature of the patwari.

Bond.

1. We will use this seed for sowing purposes only, and pay the principal together with *sawaii* interest (25 per cent.) from the produce of the crop for which we take the seed.

2. That we will pay off the principal together with the *sawaii* interest at 25 per cent. either in kind or in cash. In case of payment in cash, we shall pay the price of seed with *sawaii* interest at the rate which may be prevalent in the nearest big market at the time of payment, for seed of the best quality of the kind which we have taken. If payment is made after the 31st May then the price will be fixed at the rate which prevailed on 31st May. This rate will be determined by the officials of the Agricultural Department. In addition to this price we will pay an extra As. 12 per maund to Government.

3. If the payment of the principal with *sawaii* interest is made in kind, the seed returned shall not be inferior to that which we have taken. If the seed is adjudged inferior by the officials of the Agricultural Department, the said department shall have the right in accordance with clause No. 2 of the bond to realize the price with a premium of As. 12 per maund in lieu of the payment in kind.

4. That as soon as the crops are threshed we shall send the seed (principal with *sawaii* interest) or its price in cash to the said seed depôt. If payment in kind we shall send it on our own carts to the said depôt.

5. That we shall pay in full the *rabi* demand, principal with interest, before 31st May, and that for *kharif* before the 31st December. If the whole or any part of the price due remains unpaid after the expiry of the date fixed for the payment of the dues, interest at Rs. 7-8 per cent. per annum shall be charged on the price of the grain remaining due.

6. That if we take one or more bags from the department for taking away the seed, we shall pay for it in advance at current rate per bag.

7. That we the applicants shall be jointly and severally responsible for payment of the total demand. If the whole or any part of the total demand is left unpaid, then the Deputy Director of Agriculture shall have the power to recover it from the movable and immovable property of all or any one of us, or have the amount recovered through the Collector or Deputy Commissioner as arrears of land revenue. We have fully understood all these conditions and have duly received the seed entered in column 9 of this bond.

Sd.	Sd.	Sd.
Sd.	Sd.	Sd.

APPENDIX B.

An agreement made between ———————————son of ——————————— caste ————————— resident of ————————— in the district of ————————— of the

one part and the Secretary of State for India in Council (hereinafter called the Secretary of State) of the other part. Whereas the said ———————— has applied to the Government of the United Provinces of Agra and Oudh for a grant of Rupees ———— (Rupees ———— only) to assist him in maintaining and cultivating his seed farm described in the schedule hereto and whereas the said Government has agreed to make the said grant upon the terms and conditions hereinafter appearing. AND WHEREAS a grant of Rupees ———————— (the receipt of which the said ———————— hereby acknowledges) has been made him by the said Government. NOW IT IS HEREBY AGREED between the parties hereto.

1. During the term of five years from the date of these presents the said ———————— will grow on his said farm wheat of such kinds as the Director of Agriculture of the said Government may specify upon such areas of his said farm as the said Director of Agriculture may require.

2. During a term of five years from the first day of ———— the said ———————— will every year not later than the first week of May sell and deliver to the said Government, if so required, not more than —— maunds of Pusa No. 12 wheat grown in such fields or on such parts of his said farm as may be approved by an official deputed for the purpose by such Director of Agriculture as aforesaid and grown in such manner as such official may require, and will allow the said official to remove from such fields or such part of the said farm all plants of wheats not of the kind known as Pusa 12, and will sell and deliver such wheat upon the terms and subject to the conditions hereinafter appearing.

3. For every maund of wheat sold by the said ———————— to the said Government in accordance with the terms of the second clause of this agreement the said Government will pay him at the market rate current in the week in which the same is delivered, or in case of dispute concerning the rate then current, at the rate or price for such wheat in the district of ———— in the first fortnight of May as published in the United Provinces Gazette.

4. The said ———————— will deliver such wheat in bags containing $2\frac{1}{2}$ (two and a half) maunds each, a maund being for the purpose of this agreement reckoned as $82\frac{2}{7}$ (eighty-two and two-sevenths) pounds. The said Government will pay the said ———————— for the bags in which wheat is delivered, such price as such Director of Agriculture may determine to be the current price for bags of the kind.

5. If the said ———————— makes default in delivering the full quantity of wheat in accordan e with the terms of clauses two and four hereof he will pay to the said Government, as compensation for such default, a sum of Rupees two annas eight for every maund (of the quantity specified in clause four hereof) by which the amount delivered by him falls short of the amount specified in clause two.

In witness whereof the parties hereto have hereunto set their hand the day and year first above written.

Signed on behalf of the Secretary
of State for India in Council by ————————
In the presence of ————————
and of ————————
Signed by the said ————————
In the presence of ————————
And of————————

SELECTED ARTICLE

THE TRANSITION OF AGRICULTURE.*

BY

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THE subject of this address was not selected by me, but at the same time it seems not inappropriate to the state of affairs which we find within the agricultural industry of this country to-day. Economic conditions are such that over wide areas something has got to happen if the industry is to carry on, assuming, of course, that these conditions are likely to have some permanence; and it follows that a transition from the present condition is inevitable.

Transition periods in agriculture are to be noted all through its history, and the changes introduced in farming practice at these times have been due, all of them, to the need for industrializing the industry. The earliest is represented by the enclosure of the open fields. Open field farming had worked well enough while the business was still carried on almost exclusively as a means of satisfying the wants of the cultivator himself and the small community of which his class formed the principal part; but so soon as the opportunities for the exchange of commodities began to widen, the limitations of the system became apparent and it had to go. Enclosure was a continuous process from the end of the Middle Ages and went on even up to the present day, for so recently as 1914 an Order was made by the Board of Agriculture for the enclosure of a Gloucestershire parish. But in the history of this transition two periods of particular activity are clearly marked. The first of these occurred in Tudor times, and whilst the causes which led to it were various and time does not admit of their consideration in detail, the principal one was undoubtedly the growth of an export trade in wool. Sheep-farming on an extensive scale was impossible under the system of common field farming, and so the practice began of consolidating the holdings and laying down the plough-lands, hitherto devoted to corn-growing, to pasture. The system of sheep-ranching which followed made undoubtedly for the profit of the few, but it led to unemployment, in the absence of alternative work in urban industry, and to the scarcity of bread in the

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absence of alternative supplies of corn. This period of transition in farm organization may be said to have begun in the reign of Henry VII and to have continued into the early years of Elizabeth's reign, and much of the social legislation of the time was directed towards attempts to check it. Evidence of the importance of the trade in wool and of the profit to the individuals concerned at this time survives to-day in the " Woolpack " inn sign, and in the magnificent tombs of the woolstaplers to be seen in many of the Cotswold churches.

The second period of activity in enclosure is that which is marked by the reign of George III. It was during this time, the latter half of the eighteenth century and the early decades of the nineteenth, that the countryside came to assume its present appearance. The causes in the case were entirely different from those which brought about the Tudor enclosures. The Hanoverian farmers found themselves called upon to meet the food requirements of an ever-growing industrial population, and at the same time they had at command new crops and new methods of farming, introduced from the Continent, which could not be grown or applied under the restrictions of open field, or strip farming.

The enclosures in the early 16th century did not represent improved farming, for the conversion of arable land into sheep-walk was a retrograde rather than a progressive movement. In the eighteenth and early nineteenth centuries it marked the introduction of better farming practice. As Lord Ernle has pointed out, enclosure in the sixteenth century was opposed and arrested by legislation; in the eighteenth century it received Parliamentary encouragement and support. In Tudor times dearth of bread was the most effective cry against the movement; under George III it was the unanswerable plea for its extension.

Thus, by the time of the accession of Queen Victoria the face of the country had undergone an almost complete change, and the great fields, farmed mostly in half-acre strips for hundreds of years, as can still be seen surviving in one or two places in England to-day, had given place to the compact fields and farms as they now appear. In some places, farmers and their men have continued to live for the most part in the villages and to walk out to their fields. In most districts, new farmhouses and cottages came, in course of time, to be erected over the parish on the newly consolidated holdings, and this break-up of the village community has done much to bring about the distaste for country life which is evident in agricultural workers, more particularly in these days, when the house-wife is more dependent upon the village shop and when attendance by her children at the village school is compulsory.

By this time, the beginning of Victoria's reign, the face of the country and the organization of farming had become fairly settled more or less in its present form. Fortune varied, as it always will, and new practices were introduced with the progress of science and invention; but nothing occurred to bring about any great transition until the opening of the eighth decade of last century. The transition which then set in was very different both in its causes and its nature from the preceding

one. Whereas the changes in the eighteenth century were directed towards higher farming and were brought about by the deliberate action of the agricultural leaders of the time, the great transition of the eighties and nineties of last century was the result of declining fortune, and was forced upon a reluctant agricultural community. The causes are mostly notorious, and there were many which contributed to the final result. The development of railways in the New World, bringing vast areas of land within reach of the ports, the invention of the self-binder and other labour-saving machinery, making prairie cultivation on an extensive scale possible even in sparsely-populated districts, the increase in the production of gold, all these and other things combined to bring about a steady decline in the price of the products of arable land, wheat, for example, falling from an average figure of 56*s*. 9*d*. per quarter in the year 1877 until the year 1894 when it reached the lowest figure of the century, namely, an average of 22*s*. 10*d*. per quarter for the whole country, though at times in many markets good grain was sold even down to 18*s*. per quarter. Moreover, this period of decline had been preceded by a cycle of years of bad weather and disease, and the cumulative effect of these things was to drive out of arable cultivation no fewer than 4,000,000 acres of land, and to reduce the population working on the land by no fewer than a quarter of a million people.

All this plough land reverted in the first instance to grass, much of it by the process known as "tumbling down," which means, of course, that the land was left derelict until Nature established a herbage of her own upon it. Much of it, however, was seeded down, thus speeding up and carrying out more effectively the transition from arable to grass. No small part of it was lost to any kind of husbandry, and in the process of time became first of all covered with bushes, and finally reverted to the state of natural woodland, from which our early ancestors must at one time have reclaimed it. The figures given above indicate the magnitude of this change in the farming system of the country, but a better impression of what it has meant in the aspect and life of the country-side may be got by an inspection of any of the predominantly grass districts of England. Stand on a hill in High Leicestershire and look across the great grazings of that country ; motor through the clay lands of Warwickshire ; stand, again, above Dauntsey, in Wiltshire, and look across its fertile valley, or on the edge of Salisbury Plain and look across the vale of Pewsey. At each of these spots, so far as the eye can reach, there is nothing but grass-land to be seen, and every field shows the ridge and furrow formation indicative of a former period of arable cultivation. On the coldest and wettest of the clays, as, for example, in the neighbourhood of Bicester, or along the Fosse Way in Nottinghamshire, it is possible to walk through woodlands and thickets which show the same indications of tillage, though probably most of these are cases where reversion from arable farming took place at an earlier date, for a similar transition on a much smaller scale had occurred after the Napoleonic Wars, during which the prices to which wheat soared had brought under the plough considerable areas of land which lay normally outside the margin of cultivation.

This late Victorian transition occupied about five and twenty years. The heavy loss to landlords and farmers that it occasioned is common knowledge; but by the year 1906 the necessary adjustments had been made and by means of stock-raising, stock-feeding, and particularly by the development of the dairy industry farmers had re-established themselves upon a new basis, and although the agricultural industry, as it emerged, was a smaller one and probably less productive, from that date onwards to 1914 conditions were fairly stable, with a tendency to improve. Except in numbers the agricultural labourer alone had suffered no reverse during the transition period. The expansion of urban industry and the development of our Colonial Empire provided him with alternatives to farm work at home and prevented any decline in rates of wages, although it must be admitted that they remained at a comparatively low level.

The next transition, brought about by the Great War, calls only for the briefest reference. Under stress of circumstances land laid or tumbled down to grass in the 'eighties' and 'nineties' was once more brought under the plough to the extent of 1,400,000 acres; but seven years following the conclusion of hostilities sufficed to put it back again, and, as regards its area of plough land, England to-day is back once more in the position represented by 1914, with a tendency for still more land to revert to grass. A more important circumstance attending these two most recent periods of transition, and one which bears more directly upon conditions of present-day agriculture, is the intervention by the State to regulate the remuneration of farm labour. The establishment in 1917 of a central Agricultural Wages Board and, at a later date, of County Agricultural Wages Committees, with powers to fix remuneration of different classes of farm labour, has introduced a new element into the situation which, in my opinion, will be the dominating factor in the future development of rural industry.

The foregoing summarizes very briefly some of the more important transitional periods in the history of British agriculture. The facts concerning most of them are common knowledge, but no apology is needed of this summary, as some understanding of them is essential to a consideration of the present position of the industry and to a forecast of its probable lines of development. The position of agriculture to-day gives much concern to those who are familiar with it. The problem created by the break-up of so many of the great estates (during the last ten years more than 25 per cent. of the agricultural land of England has passed into the hands of new owners) is a special one which cannot be considered here; but in other respects farming over large areas is passing through a very trying time. In the ten years before the War, as already noted, farmers had contrived more or less to adjust themselves to the prevailing conditions. During the period of the War, although their business was conducted under great difficulty, their profits were substantial. But in the nine years of peace the efforts of the Government to re-establish the value of the £ sterling combined with the lack of purchasing power of the principal food-importing countries, which has made England a dumping ground of the surplus

products of the primary producers of the world, have produced a situation which, if it continues, seems bound to mark the beginning of another transitional period in agricultural organization.

Generalizations covering the whole country cannot be made. There are still certain districts in which general agriculture is being carried on profitably under prevailing conditions, and it is probably true that there are certain branches of this very varied industry which are yielding a return on the capital invested in them, in whatever locality they are practised. But even in places favourable to general agriculture, and in certain apparently successful forms of specialist farming, it is open to doubt whether the present conditions, particularly those relating to the remuneration of labour, can be expected to continue, whilst over the greater part of the country — on the "pound an acre land" — some early change in farm organization seems almost to be inevitable.

Agriculture is the second largest industry in the country, giving employment to some 550,000 workers for wages. Even in the more favoured districts it is doubtful whether the standard of comfort which it affords to these workers approximates to that of the lowest paid industrial labour, whilst over the greater part of the country the standard is very definitely inferior. Already the effects of this position are noticeable and they will become more and more serious. Although farm work is entirely free from the monotony which characterizes much industrial employment, and although it calls for a large measure of skill in those engaged in it, the low economic status which it affords is steadily driving more and more of the best stamp of rural worker to seek other outlets, if not for himself, at all events for his children. An organizer of an agricultural labourers' union may be quoted for the statement that the rural worker of to-day has come to regard farm-service for his sons (and domestic service for his daughters) as something derogatory and bearing the stamp of failure. An enquiry undertaken by schoolmasters in selected rural parishes at the instance of the Secretary for Education in a South Midlands county revealed an almost unanimous desire on the part of the parents of the boys to find employment for them in industries other than agriculture, and there is no doubt that there is a growing stigma attaching to the lad who remains in farm service, just as it is the experience of domestic servants attending dance clubs and similar social organizations that the girls from the shops and from the factories are unwilling to mix with them upon equal terms.

We are not concerned with the problem of domestic service, but as regards the farm labourer, my view is that the difficulty is almost entirely one of his economic status. The lure of the town is doubtless real, and to certain types of mind nothing will ever compensate for the interest and excitement of urban life. "I can always get all the unskilled labour I want," remarked the manager of one of the great Lincoln foundry companies, "by paying half-a-crown a week more than the farmer pays." This was before the War, and the difference will be greater now; but it is common knowledge that town life has an irresistible attraction for some. Never-

theless, it is true, probably, that if it were possible to raise the economic position of the farm labourer more nearly to that of his opposite number engaged in urban industry, the problem of the retention of the best class of rural worker on the land would be solved, and the growing stigma attaching to this form of service would be removed once and for all. Apart from the opinions quoted above there is statistical evidence of the existence of this desire to leave the land. A study of the age classes of land workers shows that the proportion represented by boys entering farming after the school age is high; and similarly that the proportion of men over 40-years of age is high. It is on arrival at manhood and during the years following that the big drift into the towns occurs. At the age of 21 the farm worker has arrived normally at the summit of his profession. It has nothing more to offer him in the way of advancement. Moreover, the spirit of the times demands more and more insistently a higher standard of comfort for the rural dweller. It is true that in England the standard is higher than in any European country. Notwithstanding all that has been said about the life of the Continental peasant, his success is based upon a standard of living lower than that of the worst-paid English farm-labourer, and his apparent content with his lot is due to the absence of opportunity for contrasting it with that of those in better circumstances. Where all are poor, all may be said to be rich, and in no country in Europe is there the striking contrast which exists in England between the economic condition of the average farm-labourer and that of his kinsmen and friends engaged in urban industry. Thus the tendency is all the time to raise the wage of the farm-worker. Public opinion demands it, the leaders of the Trades Union Movement are working for it —— for this mass of relatively low-paid labour exerts a depressing influence upon Trades Union rates in general —— and the great question is: Can agriculture as at present organized stand for it?

Under present conditions of farm organization the answer can only be "no." The opinion expressed by an experienced and well-known farmer at a recent meeting of the Farmers' Club epitomizes the views of innumerable of his fellows up and down the country:—" I think I am voicing the opinion of every farmer in this room when I say that we are willing to pay as high wages as any other class in the country if we can only afford to do so; but as everyone present knows, owing to the low price of corn, meat and other farm products we cannot pay any more. The consequence is that, round about my neighbourhood, the younger men, who have come to you as boys, go off as soon as they can into the factory. We are dependent on the elder men: What will come to us when they are gone I do not know."

The assertion that agriculture cannot pay higher wages is so generally made that it is desirable to find some way of testing it. Accordingly my colleague, Mr. Whatham, has made some recalculations of the financial results of farming, assuming that labour were remunerated at rates prevailing for unskilled workers in urban industry (obtained by the courtesy of the Ministry of Labour). For the first test a group of twenty-five farms in the Eastern Counties was taken, detailed accounts

relating to which for the year 1925 have been published by Mr. J. A. Venn. Of this group, five holdings showed an original loss, and as to the remaining twenty a recalculation of the labour costs on the basis of urban wage-rates resulted in a loss on ten of them; but the ten still showing a credit balance on the year's working included four on which this represented less than ten per cent. on the capital invested.

For the second test a group of twenty-four farms in the South Midlands was taken, accounts for which during the same period have been prepared by my colleague, Mr. S. J. Upfold. In this case, no fewer than fourteen holdings showed an original loss, and on recalculation of the labour bill on the basis of urban wage-rates, as before, three others failed to stand the test, whilst out of the seven remaining, no fewer than five showed a balance representing less than ten per cent. on the capital invested.

Taking the forty-nine farms in these two groups together, it appears that nineteen show an original loss; thirteen others show a loss when the remuneration of labour is raised to industrial rates, whilst of the seventeen remaining no fewer than nine show a balance insufficient to pay ten per cent. on the capital invested in them —a rate which must err on the low side when it is remembered that farming is a risky business and that the balance has to provide not only a return on capital, but also the farmers remuneration as manager. Thus more than eighty per cent. of the farms comprised in this sample fail to stand the test of competitive wages. It must be noted, too, that the farms in the Eastern Counties group include some on the best land in England, and that considering both groups it is probable that they constitute a sample above the general average of the country as a whole.

One interesting fact which emerged from Mr. Whatham s study of these figures is that in all cases in both groups where a loss is shown, either in the original or in the recalculated results, the actual labour bill bears a ratio of more than fifty per cent. to the value of the net output of the farm. Again on all these unprofitable farms, regardless of location, size or system, the amount of the wages bill exceeds thirty-five per cent. of the total outgoings.

Admittedly the foregoing tests are very rough and inadequate, but they may be taken as affording some confirmation of the general contention that farming cannot afford higher wages, and we are faced with the fact that more than half-a-million men, with their wives and families, are engaged in an industry which cannot maintain them in a standard of life comparable to that of their fellow countrymen.

What is to be the transition at this juncture? Direct State-aid for agriculture, either in the form of protection or subsidies, would settle the problem out of hand. For some time past fresh pork has enjoyed absolute protection in the endeavour to stamp out foot-and-mouth disease, and pigs are the only live-stock which did not sustain a heavy fall in market values during 1926. Again, the price procurable for sugar-beet makes it admittedly the most profitable arable crop (on many

farms the only one) and this is the result of the subsidy to home-grown sugar. But, in spite of these examples of what may be accomplished by artificial aids, any general system of protection for agriculture is impossible on all grounds. A nation dependent in the main on its foreign trade cannot afford the expensive home production of farming products, for its manufacturers for export are in direct competition with the farmer; the bottom has long since been knocked out of the argument that the maintenance of national health is dependent upon a flourishing rural community; it is clear from their acquiescence in the rapid decline of arable cultivation that those responsible for national defence attach no importance to the maintenance of home production from the land.

In these circumstances, and bearing in mind that the limited areas of more fertile arable land and rich grazings, together with any slight extension of the more intensive forms of agriculture, such as fruit-growing and market-gardening, are definitely excluded from our consideration of the subject under discussion, two possible directions in which the bulk of the agriculture of the country may proceed are indicated. The first of these is the steady multiplication of small holdings. The small holder escapes the great disability which faces the larger farmer to-day, namely, the necessity of paying wages in competition with the large scale industrial producer. The family farmer, to give the small holder a better title, has no wages bill. He recognizes no overtime, nor does the necessity for Sunday work affect his labour costs. He can and will work all the hours that there are, and his wife and children will contribute their labour to his enterprise in return for a mere subsistence. These are the conditions which make for the success of small holdings in all the peasant countries of Europe, and granting them, there is no reason why British agriculture should not be regenerated on similar lines. It would mean an increased population on the land, and a larger product from it; but it would mean at the same time a general lowering of the standard of living of those engaged in the farming industry. The progress of social life in England for a long time past has been in the direction of increasing the efficiency of labour by every sort of ingenuity, so as to reduce the hours of work and to increase its monetary reward, and from this standpoint an extended small-holdings policy, entailing long hours of labour for a small return, is definitely anti-social. The older political parties of the State have warmly espoused the policy, partly from a well-meaning desire to provide a ladder for the labourer, partly from a false reading of the apparent contentment of the Continental peasant, but mainly in the hope of increasing what is one of the most stable elements in the political life of the State. The Labour Party, on the other hand, will have nothing to say to small holdings. It recognizes that contrasted with standards of life in urban enterprise the small holding community can be regarded only as engaged in a sweated industry, and that the chances of any wholesale development along these lines are not only undesirable, but impossible, in a community where so much alternative work remunerated at a higher rate is on offer. A Belgian Government official after paying tribute to the great

political value of the peasant farmers of Flanders, and belauding their industry, told me that he regarded the attempt to create a similar class in England as hopeless. "There is no country in the world," he said, "where the opportunities of better paid work in other forms of enterprise are so great; on the other hand, if a man wishes still to follow agriculture there is no part of the world in which he will not find better opportunities than on an English small holding, whilst at the same time living under his own flag and amongst people who speak his own language." It cannot be denied that many men have made good on small holdings, but their numbers are relatively few, and they belong to that small class of rather angular individuals who cannot get the life they want, except as controllers of their own destinies. The transition of agriculture is not going to proceed very far in this direction.

The second direction in which change may proceed is one diametrically opposed to the foregoing. The possibility of it has been indicated already by Sir Daniel Hall, in his book "Agriculture after the War," and certain striking examples of it may already be found. It consists in the development of large-scale production either on light-land arable farms, when the work will be done mainly by machinery, thus turning the farm labourer into an agricultural mechanic, or on strong land grass farms—ranches, if you like—where the labour will consist entirely of stockmen and shepherds. If the economic status of the farm worker is to be raised it can only be by devising some system of organization for production which will increase the value of his output. Taking, first, the case of arable farming the impossibility of doing this on the great bulk of the existing units of production has been demonstrated already, but if you could separate your ploughman from his picturesque plough-team and give him the charge of an agricultural tractor, or of a steam engine, his daily output of cultivation would at once be increased to an amount which would justify the payment to him of wages comparable—other things considered — to that of the worker in urban industry. Such a metamorphosis would involve two great changes. First, there would have to be a further engrossment of holdings, a new enclosure movement, directed towards the creation of farming units large enough to give full-time employment to a steam ploughing set and a fleet of agricultural tractors. Two thousand acres of tillage would be the smallest working unit for such a system, and the upper limit might easily be five times as much. Second, there would have to be a considerable re-distribution of arable and grass land. Mechanical cultivation, to be effective and economical, is only possible on easily worked land, the kind of land, in fact, that can be worked, as it is said, any day of the year. On the more retentive soils, cultivation by steam engine, and even more by tractor, is limited to certain conditions as to dryness, and horse teams are essential to supplement the work of the machines. This at once re-introduces the very conditions from which this suggested development is the means of escape, for it lowers the value of the output of the unit of labour. There is much light ploughland to-day which could be farmed more cheaply by the

extended use of mechanical power, were it not for the fact that the farm unit is too small to justify the capital outlay necessary. Again, there are large areas of inferior light-land grazings which would give more employment, more produce, and more profit under tillage, if their cultivation in large scale units could be organized.

To be brief, the transition here projected is that there must be a movement to bring together all existing light-land arable farms and all the light-land grazings capable of being ploughed, in units large enough to admit of mechanical cultivation in the highest degree. It would call, probably, for radical change in the farm rotation, but this presents no obstacle, and the outstanding fact is that by raising the value of the output of the unit of labour it would raise the economic status of the farm worker at the same time. Moreover, the need for repair shops would create a demand for a staff of engineering mechanics, whilst the scale of operations would admit of, or even require, departmentalization in the organization which would provide the ladder for advancement which is so conspicuously absent on the small farming units of to-day, when a man of 21 has already reached his zenith.

Time does not admit of the full development of the proposal. Suffice it to say that this is no mere idea conceived after dinner in an easy chair. Many examples of this transition may be seen, particularly on the light chalk soils of the South of England. In one notable case, the nucleus of an enterprise extending now to some 10,000 acres, was a few derelict farms which had been abandoned by their occupiers during the depression of the eighties. The present controller of this great business saw the opportunity which his neighbours could not realize, and by throwing field to field and farm to farm he developed a system based on a small labour staff raised to the maximum efficiency by the free use of machinery, which has stood the test of good fortune and bad for forty years. Although there are signs that this system is spreading it cannot be described as popular, nor does it make an appeal to the lover of rural England as he has become accustomed to know it. Increasing the efficiency of labour in the attempt to justify higher wages involves a further depopulation of the countryside, and in districts where farming of this type is being practised derelict houses are common, and the country generally bears the aspect, to a certain extent, of desolation. It is a question of standards and ideals. Is it better to have two men tilling the soil by almost primitive methods for a reward considerably less than that of any other class of labour, or one man equipped by the application of all the inventions of modern science to do the same work for a more nearly commensurate wage ? In spite of the decline of the agricultural population it is probable that there are to-day too many men engaged upon the land, and this intensification of labour is but another illustration of the application to agriculture of the law of diminishing returns. One man's production is worth so much ; that of two men employed on the same area is worth proportionately less, and so on.

Nor does this system make for increased production. The extensive and somewhat rough-and-ready methods which it entails does not tend to make the best use of the land, measured quantitatively. But here, again, agriculture is up against the law of diminishing returns, and in the face of falling markets it is probably true that in many cases production from the land is being forced too far. The basis for the argument for the transition suggested here is that British agriculture has got to fall into line with other industries as regards the standard of comfort it affords to the workers engaged in it; and if this can only be achieved by the adoption of methods which result in a lower standard of productivity and in a reduction of employment, the sooner the facts are faced the better.

Now let us turn to the other direction in which this transition of agriculture may proceed—that of stock-farming on grassland. Much of the land of the country is unsuited to the development of arable farming mainly by mechanical power. It has been pointed out that for work of this kind it is essential to start with land which can be tilled, if necessary, on almost any day of the year; and some other system is needed upon soils of other types. The suggestion with regard to them is that they should be handled in considerable areas as stock ranches. This again would involve a considerable degree of engrossment of holdings, and the laying down to grass of much of the colder ploughlands. Here there is no opportunity for the utilization of mechanical power and agricultural mechanics on any scale; but the opportunity for the economic advancement of the labourer would come in other ways. In the first place an increase in the size of the general run of grass holdings would reduce the number of persons which they have to support. On many of the existing farms the work of management may be said to cease with the end of the summer grazing season, and not to begin again until the following spring. In this way it may be said that there are too many managers to be supported and in general the conduct of operations on a scale much larger than that now customary would result in economics, which could be reflected in the rate of wages. Apart from this, however, the stockmen and shepherds have always been the highest paid class of labour on the farm. The degree of skill and intelligence required of them is higher than that of their fellows, their hours of work are longer. Thus, whilst the opportunities presented by large-scale arable farming for raising the efficiency of labour are largely absent in the case of grass-ranching, it seems likely that the special conditions attaching to the work of a stockman and shepherd will secure for him that higher rate of remuneration which everyone must agree has got to come. The case for an increase of wages is not so strong as applied to this class of labour, for it has always commanded a higher reward; but the transition suggested would lead to the laying down of much arable land which cannot be cultivated to do economic justice to the ploughman at the present level of commodity prices; and, moreover, by a large scale organization similar opportunities of advancement would be afforded, by division of labour and departmentalization, which are impossible on the smaller grass farms of to-day.

Again, it should be said that this is not an imaginary picture of what may come about, but that many examples already exist of farming on these lines. They, too, are not attractive regarded from the conventional standpoint of what farming should be. Derelict farm-houses and deserted villages make no appeal. But England has survived changes equally drastic in the past and may have to do so again.

I do not want to give the impression that I look forward to a time when the country will be divided between great arable holdings farmed by mechanics, and great grass ranches staffed by cowboys. The fertile fen-lands, the fruit-growing and market-gardening districts and other regions, possibly, where agriculture has already been industrialized, or where the land is abnormally productive, will work out their own methods of evolution. Nor do I expect the changes indicated as likely to be brought about in a short space of time. It took 100 years to effect the enclosure of the common fields. It required a generation to lay down four million acres of ploughland rendered unprofitable during the agricultural depression. But if you are prepared to grant that agriculture can expect no favoured treatment from the State, whilst at the same time that it must organize itself so as to give those engaged in it a standard of life commensurate, at least, with that of their fellow-countrymen engaged in other industries, then I want to suggest that a transition in two directions such as those which I have briefly indicated is inevitable, and that much hardship and even suffering may be averted if we face the situation and prepare ourselves to meet it.

NOTES

ACCUMULATION OF NITROGEN IN GRASSLAND IN INDIA.

DURING the course of work on the formation and disappearance of nitrates in the black cotton soil at Nagpur, a large number of analyses was made of the total nitrogen content of the soil.

Frequently in the black soil country, one finds borders of fields and *kachha* roads which have become overgrown with grass. It is a matter of common observation that, when these old grass roads are ploughed up and taken into cultivation, the crop on that area is much larger than that obtained in the land which has been in continuous cultivation. We have shown in work about to be published elsewhere that the annual fixation of atmospheric nitrogen on the black cotton soil at Nagpur must be very large. It was found by Hall [1] many years ago that, when a portion of the Broadbalk field at Rothamsted was allowed to go out of cultivation, wild vegetation established itself and the total nitrogen content of the soil increased considerably.

It occurred to us to determine the total nitrogen content of the soil from a number of *kachha* grass roads and from cultivated soil just off the roads.

The following figures summarize the results.

Per cent. total nitrogen on dry soil.

	Grass road		Neighbouring cultivated field	
	Surface soil 0-6″	Subsoil 6-12″	Surface soil 0-6″	Subsoil 6-12″
Samples of soil from *kachha* grass road on the Nagpur Farm, Central Provinces	0·0714	0·0441	0·0539	0·0429
	0·0745	0·0528	0·0592	0·0488
	0·1260	0·0634	0·0621	0·0487
	0·0771	0·0677	0·0561	0·0473
	0·0799	0·0661	0·0581	0·0482
	0·0878	0·0587	0·0600	0·0487
Samples of soil from Kheri Farm, Jubbulpore, Central Provinces	0·0503		0·0403	
			0·0471	
	0·0559		0·0439	
			0·0403	

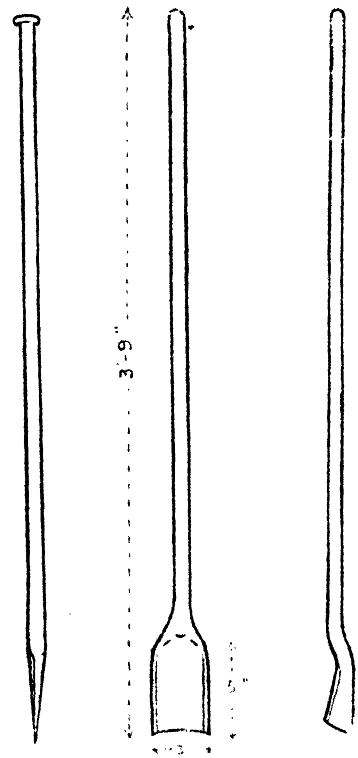
It will be seen from these results that, when cultivated land is allowed to run wild, an accumulation of nitrogen takes place similar to that found by Hall at Rothamsted. [H. E. ANNETT and A. R. PADMANABHA AIYER.]

[1] *Jour. Agri. Sci.*, Vol. I, 1905, page 241.

AN IMPROVED PITTING CROWBAR.

PROPPING of sugarcanes against lodging is an item of some importance in the cultivation of this crop in localities subject to high winds. The importance of this operation in certain localities will be obvious from the fact that, in parts of the Godavari District in the Madras Presidency, sugarcane growers are known to spend as much as Rs. 80 to the acre on this operation alone. The kind of work in progress at the Imperial Sugarcane Breeding Station at Coimbatore renders it necessary to prop almost the entire cane crop at the station[1] at a fairly early stage of the crop and in an effective manner.

The planting of bamboo uprights in the ground is an essential item in the operation and involves the digging of a very large number of pits for receiving the bamboo uprights. These pits are generally circular in shape, 5″ across and 24″ deep, and, till recently, used to be done with the tool called a 'crowbar' (Fig. *a*).



a *b* *c*

[1] Venkatraman, T. S. A cheap and efficient method of propping sugarcanes. *Agri. Jour. India*, Vol. XVII, Pt. IV, p. 416.

My constant touch with the digging of such pits has enabled me to make a slight alteration in the tool with the object of making it more efficient for work. The alteration is illustrated in the two sketches (Figs. *b* & *c*) which represent the front and lateral view of the improved crowbar. Any ordinary crowbar (Fig. *a*) can be heated and beaten to the improved shape. In the improved crowbar the functioning end is beaten into a broad segmental scoop with a bend where it passes into the stem as shown in the picture.

This was first designed by me in 1924 and is now a favourite among the labourers. The scooplike end makes it more efficient both in digging and in the removal of the dug earth from the pits. It has been found that, whereas with the old type, with the pointed end, a man can do only 25 pits in a day, he can do about 40 with the improved design. (L. K. NARAYANAN.]

PRODUCTION OF SUGAR IN INDIA BY MODERN REFINERIES AND FACTORIES DURING 1925-26.

THERE were 33 modern sugar concerns in India in the year 1925-26 capable of refining *gur* or raw sugar. Out of these, 19 worked during the season. Ten of these are situated in the United Provinces, 3 in Bihar, 4 in Madras and 2 in the Punjab.

The figures of *gur* or raw sugar melted, sugar made and molasses obtained in the whole of India during the season 1925-26 are given below as compared with the previous two seasons. The figures for the concerns in the United Provinces and Bihar are also given separately for the information of those interested.

	1925-26	1924-25	1923-24
(1) *United Provinces*—	Md.	Md.	Md.
Gur melted	1,087,827	1,204,762	1,755,114
Sugar made	532,335	541,638	816,097
Molasses obtained	442,015	511,265	752,616
(2) *Bihar and Orissa*—			
Gur melted	208,907	nil	459,746
Sugar made	98,830	..	215,584
Molasses obtained	83,673	..	181,980
(3) *Whole of India*—			
Gur melted	2,011,928	1,863,242	3,274,606
Sugar made	1,047,420	916,121	1,538,304
Molasses obtained	741,484	724,279	1,329,498

It may be noted that while none of the Bihar sugar refineries worked in the previous season, 3 were able to resume operations during 1925-26.

A note published by the Secretary, Sugar Bureau, in "The Agricultural Journal of India," Vol. XXII, Pt. I, gives the total quantity of sugar produced by factories making sugar direct from cane for the two seasons 1925-26 and 1924-25 as follows :—

1925-26	1,414,523 maunds or	51,867 tons.
1924-25	921,950 „ „	33,805 „

If the quantity of sugar refined from *gur* or raw sugar by modern processes in India during these seasons be added to the above figures, the total production would amount to 2,461,943 maunds or 90,274 tons in 1925-26, as compared with 1,838,071 maunds or 67,398 tons in 1924-25.

A table is given below showing the production of sugar direct from cane and by refining *gur* or raw sugar during the last seven seasons.

Year	Production of sugar		Total
	Direct from cane	Refined from *gur*	
	Md.	Md.	Md.
1919-20	628,920	1,211,274	1,840,194
1920-21	669,291	1,324,646	1,993,937
1921-22	753,638	1,303,433	2,057,071
1922-23	651,415	1,368,126	2,019,541
1923-24	1,044,856	1,538,304	2,583,160
1924-25	921,950	916,121	1,838,071
1925-26	1,414,523	1,047,420	2,461,943

A study of these figures will show that the refining industry in India is not making any progress. This is in accordance with the view expressed by the Indian Sugar Committee who were unable to take a hopeful view of the future of the *gur* refining industry in India in normal times. Sugar is a world commodity, the price of which is regulated by factors operating outside India, while *gur* which forms the raw material of refineries in India is a specially Indian product and its price has no regular connection with the rise or fall in the price of sugar.

In conclusion, the writer wishes to express his obligations to the Managing Agents, Proprietors and Managers of the various concerns for kindly furnishing the figures utilized in this note. [WYNNE SAYER.]

MAYNARD GANGARAM PRIZE FOR AGRICULTURAL RESEARCH.

LAST year, the late Sir Ganga Ram, Kt., C.I.E., M.V.O., R.B., Lahore, handed over to the Punjab Government a sum of Rs. 25,000 for the endowment of a prize to be awarded for a discovery, or an invention, or a new practical method which will tend to increase agricultural production in the Punjab on a paying basis. The property has been vested in the Treasurer of Charitable Endowments for the Punjab and is to be administered by a Managing Committee consisting of the Vice-Chancellor of the Punjab University (Chairman); the Agricultural Adviser to the Government of India; the Registrar, Co-operative Societies, Punjab; Sir Ganga Ram, and after him a nominee of the Sir Ganga Ram Charitable Trust; Sir John Maynard during his lifetime; the Director of Agriculture, Punjab (Convener and Secretary).

The interest accruing from the property shall after such deductions as are authorized by the rules framed under the Charitable Endowments Act, 1890, be payable by the Treasurer of Charitable Endowments to the Managing Committee.

The prize is to be known as the Maynard Ganga Ram Prize and is to be awarded every three years provided a satisfactory achievement is reported to the Managing Committee. It will be of the value of Rs. 3,000 approximately and competition will be open to the world.

Applications for the first award should reach the Director of Agriculture, Punjab, by the 1st of January 1929.

WOODHOUSE MEMORIAL PRIZE.

IN memory of Mr. E. J. Woodhouse, late Economic Botanist and Principal of Sabour Agricultural College, who was killed in action in France in 1917, a prize of books to the value of Rs. 85 will be awarded to the writer of the best thesis on some botanical or horticultural subject. Competitors must be graduates of an Indian University and not more than 30 years of age. Papers should be forwarded to the Director of Agriculture, Bihar and Orissa, Sabour, Bhagalpur, E. I. R. Loop, before 1st November 1927. Failing papers of sufficient merit no award will be made.

PRIMITIVE COTTONS IN MEXICO.

AN article on the subject by O. F. Cook and J. W. Hubbard in the "Journal of Heredity," Vol. XVIII, No. 12, contains a description of the cottons of North-West Mexico including—

G. davidsoni—A wild desert plant with no lint but only a short brown fuzz.

G. morrilli.—A wild cotton from the Sonora coast sand dunes.

G. diclandum.—A double branching cotton with large white petals and red petal spots.

G. hypadenum—A native cotton of Sinaloa with several new characters.

G. contextum.—A type in which the cotton is held in the open bolls because many of the fibres are attached to the carpel walls.

G. patens.—A Mexican species characterized by small open involucres.

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

DIAMETER AND TENSILE STRENGTH CORRELATION OF COTTON HAIR.

Considerable differences were found in the average diameters and tensile strength of a number of cotton hairs of the five varieties : Cleveland Big Boll, Mexican Big Boll, King, Cook and Rowden. There was a direct relation between diameter and tensile strength, the varieties with the broader hairs having the greater breaking load. Mexican Big Boll, with the greatest diameter, 22·576 microns, gave the greatest breaking load, 54·54 decigrams. The respective figures for Cleveland Big Boll were 18·836 microns and 31·43 decigrams. The correlation between hair diameter and tensile strength for all varieties was $0{\cdot}623 \pm 0{\cdot}013$ showing a positive relation. [*N. Carolina Agri. Exp. Sta. 47th Annual Report*, 1924, p. 32. R. Y. WINTERS and J. B. COTNER.]

LENGTH AND DIAMETER CORRELATION OF COTTON HAIR.

The results of a study of the relation between length and diameter of cotton hairs show that as the length increases the percentage of lint and the diameter of the hair decreases. The correlation between length and diameter of hairs in the case studied was $0{\cdot}2929 \pm 0{\cdot}03560$. The correlation between length of hairs and percentage of lint was $0{\cdot}2650 \pm 0{\cdot}03621$. Increase in size of seed was found to be slightly associated with longer hairs. The correlation between these two characters was $+0{\cdot}11303 \pm 0{\cdot}03845$. [*N. Carolina Agri. Exp. Sta. 47th Annual Rept.*, 1924, p. 33. R. Y. WINTERS and P. J. NAUDE.]

COTTON SEED COAT HAIR POPULATION : DENSITY AND CONVOLUTIONS CORRELATION.

Increased density of hair population on the cotton seed coat is difinitely associated with increased number of convolutions per inch. Increased length was found to be associated with decrease in number of convolutions per inch. The basal

half of the hair had fewer convolutions than the other half. [*N. Carolina Agri. Exp. Sta. 47th Report*, 1924, p. 33. R. Y. WINTERS and T. C. CHANG.]

COTTON SEED COAT HAIR POPULATION.

The density of cotton hair population on the seed coat was determined by cutting out a section of the seed coat of known area with a sharpened leather punch and counting the number of hairs attached to it. The results of a number of determinations showed that as the hair population increased, the hair diameter, the lint index and percentage of lint increased, and the length of hair and weight of seed decreased. Decrease in length was associated with increased diameter. [*N. Carolina Agri. Exp. Sta. 47th Annual Rept.*, 1924, p. 33. R. Y. WINTERS and L. I. HENNING.]

ISOLATION OF SINGLE FUNGAL SPORE.

A method of obtaining single spore cultures of species of *Fusarium* is described. A piece of soft glass tubing is drawn to an internal diameter slightly greater than that of the spore to be isolated. The prepared capillaries are broken up into lengths of about 3 cm. and filled by capillary attraction from a spore suspension made in warm nutrient agar. It is possible to obtain one to four spores to the tube. The tubes are examined under the microscope and broken so that each portion contains one spore only. The fragment is removed with forceps, immersed in alcohol to sterilize the outside and placed in the desired medium. A single hypha is obtained by cutting off the germination hypha emerging from the tube. [*Science*, 1926, **44**, 384. H. N. HANSEN.]

COUNTING OF CHROMOSOMES.

A simpler method of determining the diploid and haploid chromosome number of a plant is described. Ovaries or anthers, fixed for some minutes in Carnoy's fluid, are while still hot teazed out with a fine needle into carmine-acetic acid on a microscope slide, and examined some hours later when staining is sufficiently intense. The chromosome numbers of about 140 species have been determined by the method. Species of the Genus Cyclamen have chromosomes of very different sizes ; those with large chromosomes nearly all grow in colder climates than those with small ones. This confirms the suggestion that there is a connection between chromosome size and temperature of the regions of distribution of the species concerned. [*Z. Botanik*, 1926, **18**, 625-681. E. HEITZ.]

CONTROL OF PINK BOLL-WORM IN WEST INDIES [MONTSERRAT].

The results of examinations of cotton bolls collected from estate fields of Montserrat during a period of two years, which demonstrate the rapid extension of damage by *Pectinophora gossypiella*, are presented in tabular form. In the treat-

ment of cotton seed for the destruction of the pink boll-worm it was found that fumigating twice with carbon disulphide at the rate of 1 lb. per 120 cub. ft. of space, or twice with the second dose at one-half extra rate, gave comparable germination results, which led to fumigation of all the seed planted in 1923 by the double method, as an extra measure of precaution. Every ginnery was compelled to erect fumigating plant for handling the daily output of seed. [*Exp. Sta. Rec.*, 1926, **54**, 156-157; from *West Indies Impl. Dept. Agr., Montserrat Agr. Dept. Rpt.*, 1922-23 and 1923-24, pp. 17-20. A. GALLAWEY.]

PREVENTION OF ANGULAR LEAF SPOT DISEASE.

The cotton disease caused by *Ascochyta gossypii*, first described from Arkansas but since reported from other States, has been found to be dependent on weather conditions for its occurrence. Delinting cotton seed with sulphuric acid is claimed to eliminate the probability of angular leaf spot infection. [*Exp. Sta. Rec.*, 1926, **55**, 41-42; from *Arkansas Sta. Bull.* 203 (1926), pp. 44-51.]

CONTROL OF COTTON ANTHRACNOSE.

A detailed account is given of investigations on the control of cotton anthracnose by dry heat treatment methods. Preheating seed for 20 to 24 hours at temperatures of from 60° to 65° followed by 12 hours heating at 90° to 100° proved effective in controlling anthracnose without materially reducing the germination of the seed. The moisture content of the seed was found to be an important factor in the vitality of the treated seed. A machine for the treatment of seed in considerable quantity is described. [*Exp. Sta. Rec.*, 1926, **54**, 147-148; from *N. Carolina Sta. Tech. Bull.* 26, 1925, pp. 3-71. S. G. LEHMNA.]

COTTON PLANT DISEASES IN EGYPT.

An account of mycological work in Egypt during the period 1920-1922 deals extensively with the sore shin disease and more briefly with root-rot, angular leaf spot, a wound parasite of cotton bolls, some instances of *Fusarium* wilt and an instance of a physiological wilt disease of cotton. [*Ministry of Agriculture, Egypt, Techn. and Science Service Bull.* 49 (*Botanical Series*), 1925. H. R. BRITON-JONES.]

GRADING OF AMERICAN COTTON LINTERS.

The grades adopted as the official standards of the United States for American cotton linters are described. They compare seven basic grades ranging from the highest first cuts to the shortest second cuts. Linters below that of grade 7 are to be designated hull fibre. The pamphlet also contains notes on the character, "cutting" and uses of linters. [*U. S. Dept. Agric. Service and Regulatory Announcements*, No. 94, 1925, 9 pp.].

Staple standards of cotton.

A statement in favour of universal standards made by a representative of the U. S. Department of Agriculture is given. Looking at the matter from the standpoint of principle, practicability and desirability the department considered the time opportune for the adoption of such standards. However, representatives of the European Cotton Exchange and of the English Federation of Master Cotton Spinners and Manufacturers condemned the proposal as unwanted and impracticable. The Italian Cotton Association disagrees with the latter opinion. An interesting table shows the anomalies existing among the American, Liverpool, Bremen and Havre standards of length. [*Int. Cotton Bull.*, 1925, **5**, pp. 57-65.]

Hair weight and quality in cotton.

The hair weight per centimeter has been determined for a large number of cotton varieties to determine whether this measurable character could be used for judging the quality of cottons, and as a means of assisting in their identification more particularly when in the form of yarn or fabric. Although there is found to be considerable overlapping in the range of hair weight per centimeter as between the principal Egyptian and American varieties, the author is able to describe certain actual cases in which the value found, in conjunction with other data, gave useful indications both as to quality and type of cotton in commercial yarn fabric samples. The technique of the hair weight per centimeter determination is described. [*Jour. Text. Inst.*, 1926, **17**, T. 537-552. W. E. Morton.]

Strength and fineness in cotton hair.

The results reported by Kuhn (L. 1924-25) are adversely criticised and a scheme for establishing the staple length and uniformity, fineness and strength of a cotton in about 2 hours, including half an hour for the preparation of a Baer diagram, is described. The strength in grams is first determined using "the well-known Yves Henry apparatus," which is ostensibly an O'Neill apparatus. Since the measurements are made on the middle cm. of the hairs they represent the strength in the median zone. The strength per sq. mm. is then determined as follows : Two parallel lines 1 cm. apart are drawn on the surface of a cork and two slits are cut in its edges perpendicular to the lines. A prepared pull of cotton is inserted in the slits and cut along the parallel lines. One thousand of the centimetre pieces are counted and weighed and from the weight the metric number is calculated, thence the breaking length and strength per sq. mm. This is not, however, sufficient to characterize a cotton exactly, for the metric number is that of the median zones only. The average strength for the whole hair is obtained by counting out a sufficient number of hairs of, say, the 25 mm. region of the Baer diagram, to give a length of 10 mm. as before, weighing, and calculating its strength by simple ratio from the result of the Yves

Henry test. It is the strength of the whole hair which should be used in formulæ for calculating the strength of yarns, such as that of Gegauff. Results are tabulated for 12 cottons of varied types. They show that the average strength for short staple cottons is only 33 kg. per sq. mm., for medium American is 39 kg., for medium Egyptian is 45 kg., and for the long staple cottons is still higher. There is an average diminution of strength of 28·2 per cent. when the whole hair is considered instead of the median zone, and the time required for determining the average number or strength of a cotton can be shortened by simply diminishing the weight of the 1,000 centre zone pieces by 28 per cent. and calculating the ratio. For the determination of " fineness " in the median zone and considering the whole hair, surface area is calculated from the appropriate weight, 5 per cent. of this value is added to allow for the lumen and from a graph connecting area of section and diameter of circumscribing circle, calculated on the basis that cross-sections occupy 57 per cent. of the area of the circle containing them, the diameter is read directly. The method of deducing the 57 per cent. is shown. [*L'Ind. Text.*, 1926, **42,** 207-209, 264-266. JAMES DANTZER and OLIVER ROEHRICH.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

The post of Registrar in the Department of Education, Health and Lands has been converted into that of Assistant Secretary, and Rai Bahadur M. N. Chakrabarti has been appointed to it from 18th August, 1927.

The period of the temporary appointment of Dr. W. Burns as Joint Director of Agriculture, Bombay, has been extended up to 15th October, 1927.

Mr. T. F. Main, B.Sc., M.B.E., Deputy Director of Agriculture, Bombay, has been allowed an extension of leave for two months and 3 days.

Mr. W. M. Schutte, A.M. I.M.E., Agricultural Engineer to Government, Bombay, has been granted leave for six months from 1st September, 1927, Mr. C. G. Paranjpye officiating.

Mr. S. Sundararaman, M.A., has been confirmed as Government Mycologist, Madras.

Mr. Saadat-ul-lah Khan, M.A., B.Sc., Deputy Director of Agriculture, Madras, has been placed in charge of the V Circle.

Mr. F. Smith, B.Sc., Deputy Director of Agriculture, Eastern Circle, Bengal, has been allowed leave for five months from 27th August, 1927.

Mr. P. J. Kerr, M.R.C.V.S., Director, Civil Veterinary Department, and Veterinary Adviser to the Government of Bengal, has been granted leave for 12 months from 22nd September, 1927, Mr. R. T. Davis officiating.

KHAN BAHADUR FATEH-UD-DIN, B.A., Assistant Director of Agriculture, Punjab, has been granted leave for 8 months from 26th May, 1927.

DR. P. E. LANDER, M.A., D. Sc., A.I.C., Agricultural Chemist, has been appointed to act as Principal, Agricultural College, Lyallpur, *vice* MR. H. R. STEWART on other duty.

MR. D. P. JOHNSTON, A.R.C.Sc.I., N.D.A., Deputy Director of Agriculture, has been appointed to officiate as Professor of Agriculture, Agricultural College, Lyallpur, *vice* Mr. H. R. STEWART on other duty.

MR. P. N. NANDA, M.R.C.V.S., has been posted to the Government Cattle Farm, Hissar, as officer under training from 1st March, 1927.

MR. M. McGIBBON, B.Sc., Economic Botanist, Burma, has been permitted to resign the Indian Agricultural Service from 4th May, 1927.

MR. W. SMITH-ROLLO, A.M.I.E., Agricultural Engineer, Burma, has been granted leave for 16 months and 20 days from 15th July, 1927. He has been permitted to resign this appointment on the expiry of the leave.

MR. H. F. ROBERTSON, B.Sc., Deputy Director of Agriculture, Myingyan Circle, Burma, has been appointed Professor of Agriculture, Agricultural College, Mandalay, *vice* MR. W. M. CLARKE proceeding on leave.

U KYAN ZAN has been appointed to act as Deputy Director of Agriculture, Myingyan Circle, Burma, *vice* MR. H. F. ROBERTSON on other duty.

The Fifteenth Annual Meeting of the Indian Science Congress will be held in Calcutta from 2nd to 7th January, 1928, under the presidentship of DR. J. L. SIMONSEN, Professor of Organic Chemistry, Indian Institute of Science, Bangalore.

The Sectional Presidents will be :—

Agriculture.—Rao Sahib T. S. Venkatraman, Government Sugarcane Expert, Coimbatore.

Mathematics and Physics.—Dr. J. de Graaf Hunter, Survey of India, Dehra Dun.

Chemistry.—Dr. S. S. Bhatnagar, University Professor of Chemistry, Lahore.

Zoology.—Dr. B. Sundara Raj, Director of Fisheries, Madras.

Botany.—Professor M. O. Parthasarathy Iyengar, Presidency College, Madras.

Geology.—Professor H. C. Das-Gupta, Presidency College, Calcutta.

Medical and Veterinary Research.—Major R. Knowles, I.M.S., School of Tropical Medicine and Hygiene, Calcutta.

Anthropology.—Dr. B. S. Guha, Lecturer, Calcutta University.

Psychology.—Mr. Michael P. West, Principal, Teachers' Training College, Dacca.

The local Secretaries are Lt.-Col. H. W. Acton, I.M.S., School of Tropical Medicine and Hygiene, and Dr. J. N. Mukherjee, University College of Science, Calcutta, to whom all enquiries should be addressed.

REVIEWS

Principles and Practice of Yield Trials.—By F. L. ENGLEDOW, M.A., and G. UDNY YULE, F.R.S. [*Empire Cotton Growing Review*, Vol. III, Nos. 2 and 3, 1926.]

The Empire Cotton Growing Corporation have now published these two very valuable papers as a separate bulletin. The first section deals with general principles and opens with a mathematical explanation of the Theory of Sampling for the Mean. The necessity of determining the experimental error in yield trials is now generally accepted and perhaps the greatest danger at the moment lies in the routine application of the familiar formula without due consideration of its limitations. The authors give a convincing explanation of the statistical principles involved in the determination of the 'probable error' and clearly indicate when the application of the formulæ is admissible.

No less important is the second section which deals with practical considerations and procedure, and is amply illustrated with examples drawn from the authors' own experience of yield trials on cereals. Their first paper having shown the extreme care, and considerable resources, necessary to obtain accurate yield trials, the authors in this section first of all point out the undesirability of attempting yield trials unless the necessary land, care and attention can be devoted to them. They rightly state that in certain very backward countries there are many points of more immediate practical importance than statistically accurate comparisons of the yields of different varieties. They remind us that yield trials are not inevitable and that there may well be circumstances, especially in developing countries, in which formal trials may be entirely omitted and all efforts concentrated on fundamental reforms. Further they point out that the recognition of one or more markedly defective characters in an existing mixed variety may justify its replacement by a strain free from such defects without further ado. They wisely stress the great value of observation plots and that no series of replicated yield tests however carefully conducted justifies the omission to study the plant in detail. Attention is also directed to a point which is apt to be overlooked by the 'chess-board' enthusiast, namely, that the observation of crops grown in bulk is a necessary feature of variety-testing, since certain characters are hardly apparent except when the crop is grown on a real field-scale. But the authors reiterate the warning that yield figures from single observation or demonstration plots should not be depended on—if divulged at all. Returning to the formal replication plots the authors emphasize that season has its own probable error and that formal varietal trials should be repeated in at least three years. Finally, a practical example of small observation

plots and a discussion on 'chess-board' and narrow-strip trials is given, and one further practical point is emphasized, *viz.*, that it is not sufficient to evaluate experimental error, but in agricultural experiments, as in other branches of science, means must be adopted which will reduce such errors.

Considerations of space forbid further references to the numerous helpful suggestions that these two valuable papers contain. As the authors say, there is no *one* way, and no best way, of conducting work of this description. The agricultural experimentalist must decide for himself what the situation calls for and plan his work accordingly. Agricultural workers throughout the Empire will be under a lasting obligation to the authors for a clear and authoritative, though far from pontifical, explanation of a very difficult subject. [B. C. B.]

Citrus Diseases and their Control.—By H. S. FAWCETT and H. ATHERTON LEE. Pp. XII + 582. [New York and London: McGraw-Hill Book Company.] Price $5.

The authors have presented in this book a discussion of the present information of citrus diseases occurring in all parts of the world where citrus fruits are grown. One of them in the eastern hemisphere and the other in the western have investigated a large number of the diseases described in the book, so that most of the information given is first-hand gained in the field and laboratory. They have had the opportunity of observing most of the other diseases and have drawn on numerous contributions of other investigators to supplement their knowledge in this direction. The happy result is a book containing all that is valuable of the knowledge of citrus diseases and their control. The book is divided into four parts. The first part entitled "general considerations" deals with the species and varieties of citrus, the geographical distribution of the diseases, the principles of prevention and treatment, the preparation and use of fungicides, and cultural operations in relation to citrus diseases. The remaining three parts deal with the diseases (1) of the trunk, (2) of the branches, twigs and leaves, and (3) of the fruit. Each part has a key by which a disease can be identified by means of its main symptoms. Each disease is then dealt with in detail under the headings history and distribution, symptoms, descriptions of the organism causing the disease, contributing conditions and control measures.

The book is written in a clear simple style and will be appreciated by the grower who has the problems of disease forced upon him and is interested in maintaining the health of his citrus trees. The arrangement of the contents corresponds to the way in which the problem is usually presented to the grower's notice. If it is a disease of the trunk of the tree he turns to the part which deals with diseases of the trunk, and from the key decides which is the disease about which he is concerned. The

text then gives a further description which confirms his diagnosis, tells him of the habits of the fungus, insect or other organism that is the cause, discusses the factors that favour or hinder the disease and puts him in a position intelligently to apply the remedies for prevention and for reduction of loss. The 205 clearly produced illustrations, some of which are in colour, are a great help in forming a clear image of the various diseases. To those who are interested in citrus diseases from a more technical point of view the book is valuable both for the information it contains and for the references to literature contained in an extensive bibliography. [W. M.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Vegetables for Home and Exhibition, by Edwin Beckett. Pp. 430. (London: Simpkin, Marshall & Co.) Price, 15*s*. net.
2. Cotton: History, Species, Varieties, Morphology, Breeding, Culture, Diseases, Marketing and Uses, by H. B. Brown. Pp. xi + 517. (London: McGraw-Hill Publishing Co.) Price, 25*s*. net.
3. My Farm in Miniature, by George Morland. Pp. 288. (London: Faber and Gwye.) Price, 10*s*. 6*d*. net.
4. Alfalfa-grwing in the United States and Canada, by George Stewart. Pp. xxiii +517. (New York: The Macmillan Co.) Price, 15*s*. net.
5. The Physiology of Reproduction in the Cow, by John Hammond. Pp. xvi + 226 + 33 plates. (Cambridge: At the University Press.) Price, 21*s*. net.
6. English Farming: Past and Present, by Lord Ernle. Pp. xvi+506. (London: Longmans, Green & Co.) Price, 12*s*. 6*d*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs

1. The Indigenous Cotton Types of Burma, by T. D. Stock, B.Sc., D.I.C., A.R.C.S., (Botanical Series, Vol. XIV, No. 5.) Price, As. 9 or 10*d*.
2. A Study of *Fusaria* common to Cotton Plants and Cotton Soils in the Central Provinces, by Jivan Singh, M.Sc. (Botanical Series, Vol. XIV, No. 6.) Price, As. 5 or 6d.
3. Some New Indian Miridæ (Capsidæ), by E. Ballard, B.A., F.E.S. (Entomological Series, Vol X, No. 4.) Price, As. 6 or 8d.

ORIGINAL ARTICLES

THE ECONOMIC HOLDING OR THE FAMILY FARM.

BY

M. L. DARLING, B.A., I.C.S.,
Registrar, Co-operative Societies, Punjab.

How much land does a man require ? This basic question, put by Tolstoy in the best of his short stories, is the subject of this article. Tolstoy, answering it in terms of eternity, said—six feet by three. In the more finite terms of this life, the answer is not so simple. Now-a-days, we are constantly being informed how many acres the *average* man owns or cultivates, and if we are lovers of statistics, we may regale ourselves with elaborate tables (often unreliable) showing how many owners or cultivators fall into this class or that. But if we would know how much land a man and his family require in order to have enough to live on and enough to do, we shall not find the information so readily available. Yet, wherever the small holder prevails or is being established, the question is vital, for men multiply their kind with ease, but their fields with difficulty. Sooner or later, therefore, in the history of every agricultural country, there comes a time when there is not enough land to go round. The obvious sign of this is an inordinate hunger for land. When this occurs, it is as well to consider the question—how much land does a man require ? For then, unless industries can be developed, emigration encouraged, or birth control introduced, there will be civil unrest and probably a fall in the standard of living. In India, with a rapidly increasing population, 72 per cent. of which is dependent on the land, with industries undeveloped, emigration restricted and birth control hardly known, it would seem as if the standard of living, low as it is, must fall even lower. Yet, with that indifference to economic fact that is a danger of the times, there is a growing demand that it should be raised. The question of the economic holding can, therefore, be ignored no longer ; and it is as an introduction to the subject that this article has been written.

The great difficulty of the subject is that the economic holding, or, as we may call it, the family farm, depends upon so many different factors that it varies from area to area, from village to village, and some would even say, from house to house. In the single district of Ferozepore, the average holding is eight acres in the riverain country of the Sutlej and 92 on the borders of Bikaner[1]. This is because in the one there is plenty of water, while in the other everything

[1] *Fazilka Assessment Report*, 1914, p. 10.

depends upon a precarious rainfall, which averages only twelve inches a year and sometimes no more than three or four. The decisive factor is water, and in greater or less degree this is everywhere the case, for nothing can be done without it. But once it is available, other important factors come into play, the fertility of the soil, the system of farming, the supply of capital, the accessibility of markets, the habits and customs of the people, and last, but certainly not least, the local standard of living. It is impossible to consider all these factors in detail within the limits of an article, and all that will be attempted will be to determine in the most general terms the size of the family farm in relation to the more important systems of farming. More attention, too, will be paid to conditions in Europe than to those in India, as the problem has been more closely studied there and has led to more definite results. Though a number of countries will be mentioned, only three—Italy, France and Belgium—will be considered at any length ; and of these, Italy will be considered in the greatest detail, since agriculturally, as well as geographically, it is nearest India. Finally, an attempt will be made to ascertain the limits of the family farm in the Punjab. We may now begin our enquiry, and for this purpose let us enter Italy.

Italy.

EXTENSIVE CULTIVATION AND POVERTY.

In a report of the eighties which is still worth reading, Count Jacini wrote that "in the greater part of Italy, especially where extensive and promiscuous cultivation prevails, agriculture is exclusively given up to the cultivation of cereals, regardless of the fact that this is being done with implements as old as Adam, that it is exhausting the productive energy of the soil with an incessant alternation of wheat and maize, that no account is taken either of dung or of artificial manure, and that the plough-share is forced to drive its furrow through thin impoverished soils which could as well be used for profitable shrubs and trees."[1] Italy, like the Punjab, was then essentially a poor country. To-day, this poverty is confined to those parts of the country where agriculture has not progressed. There are, adds Jacini, two types of agriculture, one primitive, simple, patriarchal, extensive, self-contained, entirely dependent upon its own forces, taking from the earth and restoring nothing, leaving everything to the spontaneous action of nature, and requiring two factors only, human labour and a productive soil ; the other, intensive, worked like an industry with all the resources of chemistry, mechanics and natural science, and requiring two more factors,—intelligence and capital.[2] In its extreme form, the first is hardly distinguishable from the nomad system and is still found in the high mountain areas of Sicily, where the soil is prepared with axe, plough and fire, and after each crop left fallow for four years or more.[3]

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[1] Conte Stefano **Jacini,** *Relazione Finale sui Risultati dell' Inchiesta Agraria* 1884, XV, 43.

[2] *Ibid*, pp. 50—1.

[3] *Inchiesta Parlemeniare sulle Condizioni dei Contadini nelle Province Meridionali e nella Sicilia,* an official report in 15 volumes published from 1909 to 1911. The reference in this case is to Vol. VI (i), 117, published in 1910.

Between this extreme and the other there is every gradation of farming, and if the Italian peasant is not so poor to-day as he was forty years ago, it is largely because cultivation has been steadily progressing from the former to the latter. Where it is still extensive, poverty remains. In Sicily, the people are better off along the coast, where the vine, the orange and the lemon are grown, than in the interior where the ordinary rotation is a year of wheat followed by a year of pasture and a year of fallow. With this rotation, the basis of production is not repeated manuring but repeated ploughing. The land is first ploughed in January (unless it is being grazed) and again in March, May and July ; and it is weeded in September and sown in October. This is curiously like the Punjab, and, as in the Punjab, the ploughing is done with oxen.[1] In Sardinia, which is 'far the poorest part of Italy,' all that the peasant proprietor can do, when his land is devoted to cereals, is to repay the grain borrowed for seed and food.[2] One reason for this—and it is a reason that applies to the Punjab—is that the land is fragmented almost beyond belief. Holdings are split into 200, 300 and even 400 microscopical plots, some of which may be a mile or two apart, and in parts of the island the cactus hedges that divide one plot from another take up nearly half the cultivated area.[3] What is true of Sicily and Sardinia is also true, though in a lesser degree, of much of southern Italy. Jacini emphasizes "the wretched condition in many parts of Italy of property which has been excessively sub-divided, resulting in a regular proletariat of proprietors, badly housed and badly nourished."[4] The small holder is unable to support himself properly by his land, unless he can find some supplementary source of income. He would die of hunger, if for part of the year he did not find work elsewhere either in a town or as a labourer on one of the large estates of the plains.[5] Writing more recently, Professor Serpieri, the leading rural economist in Italy, states that this is still more or less the case wherever peasant holdings prevail. In south Italy, he says, the commonest type is a poor peasant, generally wretched, who has a bit of land and a hovel and usually some cattle, and who depends for his subsistence on paid labour or on cultivation done for, it may be, several masters in return for a specified share of the produce.[6] And even when he has enough land, he does not know how to cultivate it intelligently. In Calabria, says a report of 1909, "we have not seen one example of a rational manuring."[7] Fertilizers are very little used and implements are almost always the primitive plough and the spade. The modern plough, the reaper and the thresher are to be found on the large estates but rarely on the small.[8]

The Director General of the *Cattedre Ambulanti* informed me that where the peasant depended solely upon cereals he was not so well off as where he combined

[1] *Ibid*, pp. 117—182
[2] *Per la Piccola Proprietà Rurale e Montana*, 1921, I, 13.
[3] *Problemi Italiani*, dd. 15-2-23 (p. 270) and 1 2 23 (p. 229).
[4] Jacini, p. 68.
[5] *Ibid*, p. 27.
[6] Serpieri, *La Politica Agraria in Italia*, 1925, pp. 23—4.
[7] *Inchiesta Parlementare* (op.cit.), V, (ii), 77.
[8] *Ibid*, p. 80.

them with some form of intensive cultivation. It is one cause of the poverty of the south, that the lack of water—as in the Punjab, drought is the enemy—is a serious obstacle to the spread of intensive cultivation. But where it has been possible to substitute the cultivation of fruit, vegetables and tobacco for cereals and pastures, the standard of living has generally risen. This has not been possible to any great extent in the mountains, which embrace 37 per cent. of the area of the country. There, cultivation is mainly confined to grain and potatoes, and, as holdings are small and often fragmented, the standard of living is low, and the chestnut is still an important article of diet. In the hills, which are to be distinguished from the mountains and which cover 41 per cent. of the country, a greater variety of cultivation is possible and the standard of living is correspondingly higher. It is highest of all in the irrigated plains of the north, where farming is most progressive and the cultivation of wheat is based upon an elaborate rotation of fodder and leguminous crops combined with vegetables, dairying and the rearing of silkworms. Here intelligence, enterprise and capital have all been available, and, thanks to a favouring climate, great things have been done. In lower Lombardy, the very soil has been created by filling up swamps, and 2¼ million acres have been reclaimed at a cost of £40 an acre.[1]

The predominance of cereals and its effect upon the small holder.

As in the Punjab, cereals predominate in the cultivation of the country, and of cereals much the most important is wheat. In the five years ending 1923, out of a total cultivated area of 32 million acres[2] 17½ millions were under cereals and nearly 11½ millions under wheat.[3] Over half the cultivated area is, therefore, given up to grain; but whereas in the poverty-stricken mountains the percentage is 66, in the plains of the prosperous north it is only 27. Moreover, in the plains, the average yield of wheat is 20 bushels an acre and in the mountains only 11½.[4] One writer says that conditions in the latter are frequently so unfavourable that it yields no commercial profit; yet it continues to be cultivated, and to such an extent that in the Apennines and in the mountains of Sicily and Sardinia 2½ million acres are given up to it.[5] This is because the peasant's first care in Italy, as in the Punjab, is to grow what he and his family can eat, and as wheat and maize form the basis of his diet, he grows both if he can. When it is realized that 80 or 90 per cent. of the holdings in Italy are of 10 acres or less,[6] the predominance of cereals is explained. In the Punjab,

[1] Ghino Valenti, *L'Italia Agricola dal 1867 ad 1911*, 1911, p. 102.
[2] Excluding natural pastures (*International Yearbook of Agricultural Statistics*, 1924, p. 50).
[3] *International Crop Report*, 1925.
[4] *Problemi Italiani*, 11th September, 1923, p. 377.
[5] Valenti, p. 62.
[6] See figures collected by the Italian Ministry of Finance in 1896-97. Conditions are said not to have changed much since (A. Mortara, *I Doveri della Proprietà Fondiaria* (3rd Edition), 1912, p. 93).

conditions are much the same, and in both countries the cultivation of cereals on innumerable small holdings leads to identical results, unprogressive farming and a low standard of living.

One writer, in speaking of these holdings in Italy, says that even if they do not fail, they remain " neglected and often almost abandoned " and are of no more use to the community than to the owner who has to work elsewhere. They are too small to give a peasant's family either enough food or enough work. Still less do they allow anything to be saved for an emergency or for development. " Without vigour, without credit, lacking economic value and, if one may say so, moral value also, they actually make a state of bankruptcy seem the most natural condition of the peasant proprietor." The problem, he adds, might be left to solve itself, if small proprietors were not so numerous, if they were not always increasing through the division of their lands, if they did not prefer a life of humiliation and hardship to sale, and if the landless were not constantly buying small parcels of land.[1]

Types of intensive farming.

Broadly, if the small holder is to be maintained on his land with enough to eat and enough to do, farming must be made more intensive in one of three ways. Either cereals must be eliminated altogether and the holding converted into a market-garden, or they must be subordinated to the cultivation of fruit like the vine, the orange and the lemon, or of special crops like tobacco and the potato ; or finally, they must be combined with fodder and leguminous crops and supported by the breeding and fattening of stock. The first two systems belong to the type of cultivation called by the French ' petite culture,' and are based mainly or entirely upon horticulture. The third, which we may call mixed farming, is based mainly upon the production of meat and wheat. All three are intensive in character, but whereas the first two depend more upon the intensive application of labour than of capital, the third depends more upon the intensive application of capital than of labour. Till recently, the tendency in Italy has been more in favour of the former than of the latter. This, no doubt, is largely because Italy has exceptional facilities for growing fruit and vegetables. But it is also due to the rapid growth of population which has led to an excessive sub-division of holdings. The smaller a holding becomes, the less the cultivator depends upon capital, which he raises with difficulty, and the more upon labour, which is his chief asset. He turns, therefore, more readily to the cultivation of fruit and vegetables than to the more intensive forms of arable farming, which demand a good deal of capital. Market-gardening, too, will support a larger population than any other form of cultivation. In the country round Naples there are 1,288 to the square mile,[2] which is denser than anything to be found in the Punjab. Presently, we shall see how this population lives.

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[1] Mortara, *ibid*, pp. 99, 100, 309.
[2] *Inchiesta Parlementare*, 1909, IV, (i), 272.

Market gardening.

Vegetables in Italy are grown in two ways, in rotation with cereals, *e.g.*, asparagus, artichokes, cabbages, cauliflowers, tomatoes, onions, celery, watermelons and cucumbers, or in regular vegetable gardens.[1] There are about 375,000 acres under the former, and perhaps 150,000 under the latter. In both there has been an immense development in the last 30 or 40 years. The export of fresh vegetables rose from 13,750 tons in the eighties to nearly 250,000 tons in 1912-13, and the export of pickled vegetables from 600 to over 70,000 tons. Most of the latter were tomatoes, and it is characteristic of the development that has occurred in this class of farming that by 1912 sixty-one tomato factories had been established with an annual output of 10,000 tons.[2] This development could not have taken place without a great improvement in communications and a rapid growth of urban markets. Round every town there is a girdle of market-gardens, and the larger towns with the help of the rail often draw part of their supplies from a distance. The vegetables of Lombardy, Tuscany and Naples all find their way to Rome, and early potatoes cross the Alps into Switzerland and Germany[3]. But, apart from a few areas in Liguria, Venetia and Campania, where market-gardening has become highly specialized, it is rare to find vegetables grown on any scale away from a town. Even round Rome, the vegetable radius is not more than 10 or 12 miles, and so marked is the contrast between the neighbourhood of a town and the open country that to the traveller the sudden appearance of the market-garden is as sure a sign of the approach of a town as it is in the Punjab. But there is this difference between the two countries: the Italian peasant will generally grow a modicum of vegetables for himself and his family, and even a townlet is sufficient to make him grow them for others. In the wild uplands of Basilicata and Campania, though the townlets (there are no towns) are often perched so high that it takes hours of climbing to reach them, the fruit and vegetable garden plays an important part in the system of cultivation.[4] In Umbria, where the standard of living is higher, vegetables are actually grown for sale in the villages,[5] but this would not appear to be common elsewhere.

The Bay of Naples and fragmentation.

The paradise of the market-gardener is the strip of country which stretches inland from the Bay of Naples to Caserta. This is perhaps the most intensively cultivated area in Europe, a fact which is due to the fertility of the soil, famous even 2,000 years ago, and to the intensity of the labour brought to bear upon it. The density of the population per square mile varies from 500 to 1,100[6] and in one area touches

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[1] *L'Italia Agricola e il suo Avvenire*, 1920, II, pp. 181, 183.
[2] *Ibid*, pp. 183, 190.
[3] *Ibid* p. 186.
[4] *Inchiesta Parlementare*, IV, (i), 76.
[5] My informant was an expert at the International Institute of Agriculture, Rome.
[6] *Ibid*, IV, (i), 68.

nearly 1,300. The land is so fertile that from $1\frac{1}{4}$ to $2\frac{1}{2}$ acres suffice to maintain a market-gardener and his family.[1] In 1909, in the seven communes round Naples, out of 13,275 proprietors 69 per cent. had less than $2\frac{1}{2}$ acres,[2] and in the rich volcanic island of Ischia, which with Capri helps to guard the mouth of the Bay, 10,300 acres are divided into 6,356 holdings giving an average of little more than $1\frac{1}{2}$ acres each.[3] Not all these holdings are market-gardens, and many are so small that to live the cultivator is obliged to work for others. Comparatively few were well off before the war. Men have multiplied too fast and are too thick upon the ground. As invariably happens in India, the blessings of nature have been neutralized by the increase in population. And, as in the Punjab, great fertility is accompanied by excessive fragmentation. Great fertility allows for a wide variation of soils; and where, as in Italy and the Punjab, the laws of inheritance prescribe the equal division of property, variety of soil leads inevitably to fragmentation, as each heir claims a share of the better lands, which means that he must also have a share of the worse. This is the case with the country round Naples, and, it may be noted in passing, it is also the case with the rich garden lands round Jullundur which are as much split up as any land in the Punjab. Round Naples, each heir tries to get his share of every bush and field, and the smaller the holding the more he tries, so that every kind of land, arable, vineyard, garden or pasture, has to be split up into as many plots as there are heirs.[4]

A point to notice is that there is less check upon fragmentation when cultivation is based upon labour rather than upon capital, for in relation to a farm and its buildings labour is more divisible than capital. This suggests that it would be wise in India to consolidate the smaller holdings before developing them intensively, for the latter may make the former more difficult. In Campania, the combination of fragmentation and small holdings has kept the standard of living down and has led to much emigration. Peasant proprietors may be better off than tenants, but those who can live entirely on their own land are in a minority. Most of them have either to take land on lease or to work as labourers. Or a member of the family has to emigrate and send his savings home.[5]

The Market-Gardener's Standard of Living.

The intensity of cultivation in Campania is a remarkable tribute to the energy of man; but it is a question whether a comfortable standard of living, as the term is now understood, is possible to the market-gardener. All over the world his life is a hard one, and it affects the whole family. In Campania, the wife of the small holder, whether proprietor, tenant or labourer, has to work without ceasing. When

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[1] *Ibid*, p. 75.
[2] *Ibid*, p. 168.
[3] *Ibid*, p. 164.
[4] *Ibid*, pp. 163, 225.
[5] *Ibid*, p. 191.

obviously pregnant, she can be seen washing the family linen at the public fountain and even carrying a large bundle of it home. She works almost to the hour of her delivery and fifteen days later starts again. Often beautiful at 15 or 20, she is faded by 30, old by 40, and decrepit by 55. The house cannot be kept clean, for the family baking and cooking have to be done in addition to work in the fields, and children have to be tended and not infrequently nursed. When this is the case, the infant is taken to the fields and deposited in the shade of a tree while work proceeds, and as nursing continues for 18 months or two years, the strain is great. As soon as a child can walk, it is handed over to an old woman who looks after it with ten or twelve others for halfpenny a day.[1] Only those who own a good deal of land escape the unending burden of toil, and the wife of the tenant fares worse than the wife of the proprietor, as a high rent has to be paid and it is paid partly out of her labour.[2]

MIXED FARMING.

Since the war, everyone wishes to be more comfortable and do less work. The life of the market-gardener, therefore, is no longer held up as a desirable state. At the same time, there is everywhere a movement in favour of the small proprietor as against the large on the one hand and the labourer and tenant on the other. This means the multiplication of small holdings and raises in a crucial form the question how a higher and more comfortable standard of living is to be obtained on a small holding. The remedy advocated is the mixed farm intensively cultivated; and, as this requires capital and a compact holding, two more remedies are prescribed—co-operative banking (to eliminate the usurer) and consolidation. The mixed farm depends primarily upon an elaborate and scientific system of rotation. It may perhaps be doubted whether this is feasible upon a holding of a few acres, but it is clearly impossible when the few acres are split up into plots scattered all round the village. All writers, therefore, insist upon consolidation as an indispensable condition of development. The provision of capital is also important. Professor Serpieri reckons that with cereals the conversion of extensive cultivation into intensive requires 400 lira per acre for the simplest start and from 1,600 to 2,000 to do it well.[3] Cattle have to be partially stall-fed instead of being allowed to pasture wild; well-drained byres have to be built; manure has to be stored and supplemented by artificial fertilizers; water has to be economised by a system of carefully constructed channels, and fruit trees have to be planted.

THE PROBLEM OF WORK.

The problem, as already stated, is to give the small holder not only enough food but also enough work. When cultivation is extensive, periods of idleness alternate

[1] Before the war, this was also the custom in East Prussia, see *The Solitary Summer*, 1899, p. 119.
[2] *Ibid*, pp. 262-64.
[3] *Per La Piccola Proprieta Rurale e Montana*, II, 255. In 1922, when this volume was published, 100 lira was worth about £1, but when Professor Serpieri wrote, it was probably worth at least £2.

with periods of overwork. In the former, every kind of mischief is hatched, and in the latter, the family is overworked or the work is badly done. In the Punjab, it is doubtful whether the small holder ever does more than 200 full days' work in the year, unless he cultivates his land intensively. In Japan, though farming is sufficiently intensive, he does not seem to do very much more.[1] In Sicily, where there is no intensive farming, he does only 150 to 200 days' work.[2] In south Italy, the period depends upon the nature of the farming. In the Abruzzi mountains, where there is a long winter and farming is simple, it varies from 180 to 200 days [3]; but wherever fruit is combined with grain, it runs from 200 to 250[4], and where, as in the country round Naples and along the coast of Sicily, 'petite culture' prevails, it touches 260.[5] From this point of view, therefore, the market-gardener and the fruit grower have an advantage over the arable farmer ; but monoculture, as this form of farming is apt to be, is a risky business, for if anything goes wrong with seasons or markets, the cultivator, with only one sail to his boat, may find himself on the rocks ; whereas in a country like Italy, which has a considerable urban population and imports a large amount of grain, a market can always be found for meat and wheat.[6] For the small holder, therefore, the mixed farm has two advantages over the market-gardener : it provides a more confortable life and a less risky business. And in a country in which the cultivation of cereals is necessary, it is also a protection, for cereals suit the large farm better than the small, and if the small holder grows nothing but grain, he runs the risk of being driven out by the large.[7] In the Abruzzi mountains, the customary rotation of wheat, maize and potatoes is being modified by the introduction of leguminous crops, such as clover, sainfoin, and lucerne ; and at the same time, an attempt is being made to substitute stall-feeding and cultivated grasses for the immemorial custom of everyone's cattle being pastured together, a system that is bound up, as in India, with fragmented fields and an unscientific rotation.[8] Generally speaking, it may be said that at present all over Italy, where cultivation is still in a primitive or semi-primitive stage, the main effort of the Agricultural Department is in this direction, and, as has been shown elsewhere, Mussolini's wheat campaign is being fought on identical lines.[9]

The importance of fodder crops.

It seems that very few peasant proprietors are able to support themselves from their land by the cultivation of cereals only. Nearly all combine it with some form

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[1] See Robertson Scott, *The Foundations of Japan*, 1922, pp. 64, 237.
[2] *Inchiesta Parlementare*, VI, (ii), 21.
[3] *Ibid*, II, (i), 109.
[4] *Ibid*, V, (ii), 270 and III, (i), 312.
[5] *Ibid*, IV, (i) 279.
[6] Valenti, p. 108.
[7] *Inchiesta Parlementare*, III, (i), 737.
[8] *Ibid*, II, (i), 27.
[9] See the writer's article on the *Cattedre Ambulanti* in *The Agri. Journ. of India*, July 1927, p. 253.

of intensive cultivation, and in grain areas the progress of agriculture may almost be measured by the part played by fodder and leguminous crops in the local rotation. The development of these crops is important, not only because it increases the productivity of the land, but also because it encourages cattle breeding. In Umbria, and no doubt elsewhere, the *métayer* tenant pays his way with his crops but for his surplus looks to his stock—to the cow he milks, the calf he fattens and the pigs and poultry he breeds.[1] Presently, we shall see that the same is true of many peasants in Belgium and France. Valenti says that the cultivation of cereals requires the support of cattle breeding,[2] and for this the extension of fodder crops is naturally essential. It is one of the causes of the greater poverty of the mountains that fodder crops represent only 10 per cent. of the cultivation, and as the mountains include rather more than one-third of the total area, this affects the whole country.[3] In the south and the islands, fodder crops play an unimportant part and cereals almost always alternate with pasture, or, in Sicily, with the bean. The following figures show the effect of this upon the yield of wheat and maize[4] :—

	WHEAT	MAIZE
	(Bushels per acre)	(Bushels per acre)
Alps	16	28½
Northern Apennines	15¾	19½
Southern ,,	10¾	13½
Sicily	11	9½
Sardinia	10	..

Professor Serpieri, following Valenti, lays equal stress upon the development of fodder crops and says that throughout Italy there is a want of equilibrium between their cultivation and the cultivation of cereals. The aim, he says, should be to create "in mountain, hill and plain" the conditions likely to promote a great development of cattle breeding, and he pertinently observes that the object of this is not to increase one particular means of production but through an agricultural system 'meglio equilibrata e rinvigorita' to increase production under every head.[5] How this can be done has been explained elsewhere.[6] The policy has been widely applied in the Alps and with the happiest effect upon production. Professor Serpieri goes so far as to say that it is the real agrarian revolution that has taken

[1] Information given me by the expert referred to above.
[2] Valenti, p. 107.
[3] *L'Italia Agricola*, II, 9.
[4] *Ibid*, II, 10.
[5] *Ibid*, II, 49, 51, 53, 61.
[6] See the writer's article referred to above.

place in northern and central Italy and in many parts of Europe.[1] But it has hardly begun in the southern Italy, where the cultivator barely knows of the existence of hay and of the possibility of stall-feeding.

SIZE OF HOLDINGS.

From what has been said, it is perhaps clear that, broadly, there are three types of cultivation practised by the small holder in Italy: firstly, the extensive or primitive system of farming to be found in the southern Apennines, the uplands of Sicily and Sardinia: secondly, the horticultural system associated with market-gardening, the vine-yard and the orchard, in which labour rather than capital is intensively applied; and, finally, the system of mixed farming, in which the emphasis is more upon capital than upon labour. We must now consider how much land is required to support a family in any comfort in each of these categories.

We have already seen that round Naples, where market-gardening prevails, a family can live, though not very comfortably, upon an acre or two of land. On the Bay of Salerno, where cultivation is almost equally intense but depends more upon fruit than upon vegetables, four to five acres are required, and where the orange and the lemon are grown, 2½ suffice.[2] So, too, all along the sunny slopes of the hills that look out over the Mediterranean, provided that water is available. In Apulia, where the climate is dry, it is calculated that when cereals are planted between the vines and there is a small garden as well, 12½ acres are required to give a family of five enough food and work and 25 acres of pasture will be needed in addition for the necessary flock of 25 sheep.[3] In Calabria, where cereals are grown between fig, olive, mulberry and vine, and the land is not irrigated, 10 to 25 acres are required,[4] and in Sicily the corresponding figure is 15 acres.[5] The report, from which these figures are taken, mentions an area in which out of 1,200 families occupying less than 2½ acres only 69 were well off. In Central Italy, where the vine and the olive are admirably cultivated in combination with cereals on the *métayer* system, the estimate of what a family requires varies from 10 or 12 acres in Tuscany to 15 to 20 in Umbria and Siena. The latter estimate applies, too, to the mixed arable farms of Modena.[6] This is of particular interest to us in the Punjab, as it corresponds closely with the average holding in the Lyallpur Colony (18 acres),[7] where the Punjab cultivator is at his best. The Modena figure is also significant because in this district everything is in favour of the cultivator: the average yield of wheat is over 20 bushels to the acre; the dairy industry is highly developed and the farmer's business co-operatively organized.

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[1] *Ibid*, II, 51.
[2] *Inchiesta Parlementare*, IV, (i), 75.
[3] *Per la Piccola Proprieta*, II, 193.
[4] *Ibid*, II, 138 and *Inchiesta Parlementare*, V, (ii), 38.
[5] *Ibid*, II, 204.
[6] A member of the staff of the Cattedra Ambulante at Siena.
[7] *The Punjab Peasant in Prosperity and Debt* (2nd Ed.), 1927, p. 148, by the writer.

Where farming is extensive, and cereals predominate, the figures are naturally much higher. In the dry areas of the south 50 to 125 acres are required[1], which may be compared with the equally large holdings on the arid borders of Bikaner. It is much the same in the Marches of Central Italy, and in parts of the Maremma the estimate touches 150 acres.[2] Even in the hilly country of Siena, where agriculture has definitely begun to progress, 35 to 40 acres are said to be necessary.[3]

These figures are rather general indications of tendencies than precise statements of fact. But they have value, as they show clearly that the amount of land which a man requires to support himself and his family, varies greatly according to the way it can be cultivated. For the market-gardener, it may be said that from one to 2½ acres are sufficient, and for the expert fruit-grower and cultivator of industrial crops like tobacco four or five acres. But where cereals play at all an important part, the minimum is 12½ acres, and it is only as low as this where the vine is grown as well. Where the farm is entirely arable and a fairly high standard of living is maintained, it is nearer 20.

(*To be continued.*)

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[1] See *Inchiesta Parlementare*, IX, (i), 74 ; V, (ii), 152.
[2] *Ibid*, IV, (i), 73.
[3] See the writer's article referred to above.

THE ACCLIMATIZATION OF IMPORTED STOCK.

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(Concluded from Vol. XXII, Pt. V.)

It has been stated that the main factor in the acclimatization of imported animals is parasitism, and our observations prove that the most important parasites with which the animals have to contend are those known as the piroplasms.

The piroplasms are minute unicellular animal parasites (protozoa) which during a certain stage of their life-history invade the red cells of the blood. They are very closely allied to the malaria parasites of man, and, like these human parasites, they are transmitted by the bite of an invertebrate intermediate host, in which they undergo another essential stage of their life-history. As is now well known, the intermediate host of the human malaria parasite is a mosquito; that of the piroplasms of the domesticated animals is one of several species of ticks. Ticks are almost ubiquitously found, often in enormous numbers, upon the skins of animals in India, and they are a source of loss both directly on account of the sustenance they withdraw from their hosts and on account of their capacity for transmitting the minute parasites of disease. Certain ticks transmit a disease to horses known as biliary fever (due to the piroplasms *Nuttallia equi* and *Babesia caballi*); to dogs, sometimes known as malignant jaundice, very common in India (due to the piroplasms *Babesia canis* and more frequently *Babesia gibsoni*); to fowls, known as tick-fever, or fowl spirochaetosis, very common in India (due to the spirochæte, *Spirochæta gallinarum*); to sheep (not yet well studied in India, but undoubtedly *Theileria ovis* occurs); and to cattle, including buffaloes.

Our researches indicate that the indigenous cattle of India are infected almost, but not quite, everywhere with two different kinds, or genera, of piroplasms, namely, (A) *Babesia* (*Piroplasma*), and (B) *Theileria*.

(A) Babesia (Piroplasma).

The only species of *Babesia* we have hitherto been able to determine in Indian cattle is *Babesia bigemina*, the cause of the redoubtable cattle disease known variously as "Texas fever," "tropical red-water," or, simply and somewhat diffusely, "tick-fever." In Northern Europe, the common piroplasm is a smaller organism of this kind, *Babesia bovis* (or *divergens*), which is usually much less virulent. In

South America, a small highly virulent piroplasm, somewhat similar to *B. bigemina*, and known as *B. argentina*, has been recognized as a separate cause of very fatal red-water infection. (We have not been able to identify a separate species of this kind with certainty in India although we suspected its existence at one time in the course of our researches; we now believe that in advanced severe affections the *bigemina* type of parasites appears to undergo a transition in form to the more minute *argentina* type.)

B. bigemina, so-called because the parasites often appear typically within the red blood cells as a pair of, or twin, organisms, is a relatively large piroplasm, especially when compared with piroplasms of the *Theileria* genus. It is beyond the purpose of this paper to discourse upon its various morphological and biological characteristics. It was first seen by Babes in Roumania in 1888, and its life-history and other general characteristics were described in a classical monograph by Smith and Kilborne in the United States of America in 1893. Since that date, a large amount of technical knowledge has accumulated upon it. It has an almost universal distribution, particularly in tropical and sub-tropical countries. In temperate countries it is also found, but to a rare extent, however, as compared with *B. bovis*, and this for the reason that, it seems, the ticks through which it propagates hereditarily do not flourish in cold climates. In the United States of America and in Australia the common transmitting tick is *Margaropus* (*Boophilus*) *annulatus australis*,—a continuous feeder, that is, a tick that spends the whole of its life cycle from larva, or seed tick, to the adult sexually ripe stage on one host. If during this period of attachment the tick feeds on an infected host, it ingests with the blood some piroplasms, which then undergo certain stages of development, as yet imperfectly understood, in the tissues of the tick, and pass into the ovaries, and through the eggs, into the next generation of ticks. In South Africa, another continuous feeder, *Boophilus decoloratus*, has been found to be the common transmitter. No work has hitherto been done in India to determine directly the species of ticks responsible for transmission, but we have good reason to believe that the common transmitter is also *Margaropus annulatus australis*, a tick which is very common on cattle in many parts of India.

Some curious points in the infection caused by *B. bigemina* are worthy of note. If an adult beast that has not previously been infected with this species of piroplasm is injected under the skin with a few drops of blood from an infected beast, it shows after an incubation period of six to ten days—sometimes a little longer—a sharp rise of temparature of 3° or 4° F. and often more. The animal then goes off its feed and shows general signs of fever, with marked increase in the heart action, and in a day or two the urine is intensely discoloured red, due to the destruction of the blood cells and excretion of blood pigment by the kidneys. In the acute disease, the animal then shows signs of great anæmia, weakness, and dies after a few days; the spleen shows much enlargement in these cases. Sometimes, the animal may die suddenly soon after the initial abrupt rise in temperature, due to failure of heart action, with marked exudation of a clear fluid in the pericardial sac. In sub-acute cases the

symptoms are somewhat similar to those seen in the acute cases, but the animals last longer and often display marked signs of jaundice and diarrhœa before death; the spleen in these cases is not found to be distinctly enlarged *post mortem*. When recovery takes place in these cases the convalescent period is rather anxious and prolonged. The same train of symptoms is observed in distinct cases of affection when animals are infected naturally by the bites of ticks, but the incubation period is somewhat longer, 15 to 20 days.

The course of symptoms in calves is generally much milder. After infection there is often scarcely any outwardly visible disturbance, but if the animals are kept under observation during this period a distinct febrile disturbance may be recorded by means of a thermometer. With advancing age, susceptible animals become increasingly sensitive towards the effects of infection, until when they attain the age of about two years they suffer from the acute affection in much the same way as adults. Occasionally, however, outbreaks of the acute affection have been recorded in quite young animals, due apparently to especially virulent strains of the piroplasms, and we have outbreaks of this kind among young calves under investigation in India. In these outbreaks, the piroplasms are often rare in the blood, and it has been assumed that they cause their baneful effects by rapid multiplication in and occlusion of the blood capillaries in certain important internal organs, notably the brain and kidneys. However, the relative immunity of young animals is a phenomenon of fundamental importance in the study of the so-called acclimatization of cattle imported into enzootic areas.

It may be stated here, parenthetically, that our own experience in India shows that indigenous cattle not infrequently succumb to *bigemina* infection, as disclosed by systematic microscopic examination, particularly as a sequel to rinderpest, with symptoms of suddenly occurring fever or collapse, with rapid death or rapid recovery, that do not conform with those described above for adult imported cattle. It is probably for the reason that the disease often runs an aberrant course of this kind that veterinary workers in India have not regarded it hitherto as a potentially serious infection of indigenous stock.

Cattle that have recovered from an attack are subsequently immune for the rest of their lives against further attack, but the immunity developed is a peculiar one. In the case of the immunity developed by animals against certain other infectious diseases, such as rinderpest, blackquarter, hæmorrhagic septicæmia, or anthrax, the affected animal after recovery cleanses itself completely of infection, or, in other words, of the specific parasites, and develops powers of complete resistance towards their subsequent re-entry into its system. The immunity developed after recovery from *B. bigemina* infection is different: if a little blood is taken from an apparently recovered animal and injected into a beast that has not been infected previously, a typical attack of red-water is set up, showing that the parasites still persist, in very small numbers, in the blood of the recovered animal. It has been found by experiment that the blood of an animal is infective in this way for periods extending

to 12 years after the original attack. Furthermore, ticks feeding on such animals may contract infection during the whole of this time, and may transmit virulent infection through their progeny when the next generation bites a susceptible beast. The recovered animals are therefore persistent " carriers " of infection.

The piroplasms have established in this way a state of equilibrium with the tissues of the " carrier " cattle, wherein they persist in very small numbers, by a subdued rate of multiplication, for many years. The state of equilibrium may become violently disturbed, however, sometimes, as when the " carrier " cattle become attacked with rinderpest; in this disease the restraint maintained on the parasites is relaxed, with the result that they may multiply unimpeded, and the complicating infection thus set up by the resuscitation of the piroplasms may contribute towards a speedy fatal termination of the rinderpest attack. We have observed this complication to occur extremely commonly at certain seasons among cattle infected with rinderpest at Muktesar, so as to render it difficult to judge the intensity of the rinderpest syndrome *per se* in the infected animals.

The process of acclimatization in so far as it refers to the resistance of cattle towards *B. bigemina* infection is easily comprehensible. In enzootic areas, cattle become infected almost with certainty as calves or young animals by the bites of infected ticks, contract a mild or inappreciable attack of disease, and are thereafter immune, although they remain carriers of the parasite. In areas where the enzootic state is not so intense, presumably through the comparative rarity of ticks, circumstances preventing tick infection while the animals are still young, or paucity of carrier animals, cases of red-water affection may be observed to occur from time to time among the indigenous cattle; this state of affairs has come prominently to our notice in certain parts of India. We have also noticed certain small areas (parts of the Assam hills) in which the cattle are " clean," and thus are as susceptible to the effects of infection as are cattle imported from abroad; however such areas must be relatively very few.

When adult imported cattle are introduced into the enzootic areas they almost inevitably, sooner or later, contract infection from the bites of ticks that have become contaminated from the " carrier " cattle of the vicinity which are, however, in apparently good health. Sometimes, the imported beast dies suddenly, as has been reported to us, and the owner does not suspect that the fatality is in reality caused by a fulminant attack of red-water; at other times, the symptoms of red-water are clearly distinguishable.

The experience of certain countries that were heavily infested with the kinds of ticks capable of transmitting these piroplasms and had to commence their cattle-raising industry with foundation stock imported from clean countries is instructive. Perhaps the most interesting in this respect is that of Queensland. At first it was very difficult to establish the existence of imported cattle in the country on account of the very large mortality that occurred among them from red-water. The progeny of the survivors, however, flourished without mishap of this kind, and the country is

now well stocked with cattle among which the presence of red-water is not suspected; all are, however, "carriers," and cattle freshly imported into the country would again inevitably contract severe affection. The tick problem, nevertheless, has become an acute one, necessitating the employment of determined repressive measures in the form of regular dipping of cattle, with arsenical fluids. These measures are adopted not because it is wished to eradicate the piroplasm infection, but because the enormous multiplication of the ticks in itself causes a great loss of condition by withdrawing sustenance from the animals. Indeed, the authorities concerned do not aim at the complete eradication of the ticks and only wish to reduce them to such numbers that they cause very little impoverishment in the condition of the cattle. Complete eradication of the ticks in restricted localities would be bad policy, for a generation of cattle would then grow up that might escape infection until they arrived at an adult age, when they might accidentally contract infection very probably from ticks descended from other ticks that had bitten the still infected carrier cattle of the vicinity, and they might become affected in this way with severe, and probably fatal, disease.

In the Southern States of United States of America a vigorous campaign has been in progress for several years, at great expense, aiming at the complete eradication of the ticks, and the success obtained through the measures adopted marks one of the greatest feats known in the veterinary control of disease. The depredations caused by the "boll weevil" among cotton crops led the inhabitants of these States to turn to stock-raising as an alternative occupation. Cattle imported from the Northern States, however, succumbed in large numbers to the deadly Texas fever, which is *B. bigemina* infection; the annual losses from this disease prior to 1900 were estimated at over ten million pounds sterling. "State-wide" measures of control, governed by Federal legislative enactments, were imposed: all infected States were quarantined, and the cattle therein compulsorily dipped in arsenical baths at fortnightly intervals; the quarantine was not raised from any State until it was declared free of cattle ticks. The success desired seems now to have been achieved, and attention is directed at present to the extermination of the other local parasitic infections, notably those caused by the parasitic worms.

Repressive measures of the kind adopted in United States of America are manifestly impracticable at the present time in India. Further, as has been explained, attempts at the eradication of piroplasm infection by tick extermination over restricted areas may ultimately defeat their own objective by the creation of small isolated zones of clean cattle exposed to continual danger from the surrounding infected areas. Measures envisaging action against the ticks, to be successful, must be complete and uniform throughout a range of territory delimited only by the geographical confines.

The question remains, how are cattle imported into India to overcome this particular limiting factor in acclimatization? Can they be protected, or vaccinated, by any means? The answer is, yes; but this answer must be qualified somewhat.

It must be remembered that very young cattle are relatively resistant towards the effects of infection. Also, we have now at our disposal a certain drug which exerts a very striking curative action upon the disease caused by this piroplasm. This drug is a synthetic aniline dye known as *trypanblau* (or trypanblue), first found to have a marked specific effect upon the analogous piroplasmosis of dogs, caused by *Babesia canis*. When this drug is injected under the skin, in a suitable dose, or into the veins, soon after the infected animal has displayed signs of fever, a rapid drop in temperature, with marked destruction of the piroplasms, is brought about. In the serum-simultaneous inoculation of cattle against rinderpest, we now counsel operators upon imported cattle or upon cattle in areas where the operation has not been previously conducted and where the risk of complication with red-water is not known, to keep a careful watch upon the animals for a sudden rise in temperature from the 6th to the 10th day after the inoculation with the virulent blood, for the reason that this blood probably has contained the parasites of red-water and the inoculated animals may be susceptible to attack with these parasites. As soon as a febrile disturbance is detected, and without waiting for comfirmation by microscopic examination of the blood, the operator should assume that the fever is a sign of red-water attack and treat the affected animal at once with *trypanblau*. The beneficial effects of this drug treatment are illustrated in charts 2, 3 and 4. The cured animal remains a " carrier " of the parasites in the same way as naturally recovered animals, and possesses an immunity towards red-water for the rest of its life. We have also counselled the application of the serum-simultaneous inoculation against rinderpest to cattle soon after importation for the reason that when the animals are carefully observed in the manner recommended after the inoculation they may be protected afterwards not only against rinderpest but also against a risk that is still more considerable, namely, that caused by red-water.

For some years, the veterinary authorities of the Ministry of Agriculture in Great Britain have undertaken to vaccinate young cattle destined for exportation to the East against tropical red-water. The procedure is exactly analogous to that described when red-water infection inadvertently complicates the serum-simultaneous inoculation against rinderpest. The success of the procedure also depends in considerable measure upon the age of the animals at the time of vaccination. It has been stated that very young animals re-act to infection often with no more than a transient febrile disturbance. In the actual process of vaccination the young cattle are therefore inoculated with a quantity of blood taken from a specially maintained " carrier " animal; the temperatures of the inoculated animals are then taken morning and evening and when a sharp rise of temperature is observed, from the sixth to the tenth day, the severity of the reaction is controlled by timely injections of *trypanblau*. The procedure is not without a fairly considerable degree of risk, but this risk is curtailed by careful selection of a " carrier " animal that will induce the desired type of infection when a certain quantity of its blood is used for the inoculation. I any event, it will be readily conceded that it is better to face this risk

prior to exportation than after incurring upon the animals the extra expenditure involved in transport to India.

(B) Theileria.

The small piroplasms belonging to what is now regarded as a separate genus designated *Theileria* have hitherto received very scant attention from veterinary workers in India. In an article written in 1904 by the late Col. J. D. E. Holmes entitled "Some diseases complicating rinderpest among cattle in India" (*Journal of Comparative Pathology and Therapeutics*, 1904, Vol. XVII, p. 317), he describes complication with piroplasmosis but the impression gained on reading the article is that he believed he was dealing with only one kind of piroplasm, *B. bigemina*. So far as we can gather, the first definite recognition of the two great groups of piroplasms that invade the blood of Indian cattle was made in the Annual Report of the Muktesar Institute for the two years ending March 1924, the relevant paragraphs from which are reprinted below :—

(1) *Piroplasmosis.* The amount of precise information upon the piroplasms of cattle in India that was available in the technical literature was very small, considering how well these protozoan parasites had been studied elsewhere in the world. It was surprising to find that in the minds of veterinary workers the detection of any piroplasm in a blood smear from an ox was taken to indicate infection with the causative agent of tropical "red-water." At the laboratory the staff employed in the routine examination of smears from cattle that showed febrile symptoms differentiated the intracorpuscular parasites discoverable into "large" and "small" piroplasms, without giving any more exact information concerning the nature of the bodies. In the organization of the examination of routine material for research information, the supervision of microscopic diagnosis of the blood films forthcoming daily was entrusted mainly to Mr. Cooper, and a system of recording laid down, whereby indications could be obtained as to the distribution and nature of piroplasm infection in cattle used at the laboratory ; officers visiting the laboratory for training were also made to take a share in this important form of practical disease investigation. In the records of the year 1922-23, there appeared among 4,325 smears examined positive evidence of infection in 504 smears, of which 80 were stated to be infected with a large piroplasm (*Piroplasma bigeminum*) and 220 with "small piroplasms." On investigation of representative smears infected with the latter type it struck me that all the small parasites conformed exactly with the descriptions given by authorities (the Sergents and others) of *Theileria mutans.* The large piroplasm was undoubtedly *Piroplasma* (*Babesia*) *bigeminum.* The conformation of these parasites was then displayed clearly to the staffs interested with smear examination, with the result that, with increased experience, during the year 1923-24, out of 5,158 blood smears examined, *Theileria mutans* was definitely demonstrated in 1,368, and *Piroplasma bigeminum* in 244. These figures represent chiefly the proportion of microscopically demonstrable infection in cattle passing through a rinderpest reaction, and hence may be regarded to a considerable degree as indicating parasites resuscitated by the tissue depression from their dormant or "carrier" state. Much information is, however, required concerning the infectivity and pathogenicity o parasites designated by the name *Theileria mutans.* It is not improbable that all cattle in India are infected with this kind of parasite, and that the infection is not productive of any serious effects upon the host. It is important to impress upon the minds of field workers, particularly those who are in charge of the active .mmunization of cattle against rinderpest, that the detection of these small piroplasms in the blood even in relatively large numbers, is not necessarily a sign that the animal is exposed to grave

risk. Infection with the large piroplasm, however, even in small numbers, or in numbers too small to be detected by an ordinary microscopic examination, may be fraught with serious consequences, and steps should be taken immediately to forestall its further development; fortunately we now have in ***trypanblau*** a drug which checks most effectively disease due to the parasite provided it is given in timely, adequate doses. In the routine instructions issued from the laboratory for the active immunization of cattle against rinderpest it is now recommended, therefore, that animals showing a sudden rise of temperature after injection of the virulent blood, derived probably from a bovine infected with the red-water piroplasm, should be administered ***trypanblau*** if they show any suspicious sudden rise of temperature at the expiry of the presumed incubation period of infection with this parasite, seven to ten days usually after the injection.

A discovery of very considerable importance was made by Mr. Cooper in the course of the organized examination of routine pathological material at the laboratory. On June 12th, 1922, a hill bull was examined *post-mortem* that had died 17 days after inoculation with rinderpest virus, and the lesions discoverable bore a suspicious resemblance to those of the East Coast fever of African cattle. Microscopic examination of the lesions revealed in abundance structures quite indistinguishable from the so-called 'Koch's blue bodies' associated with the African disease and an extremely rich infection of the red blood cells with piroplasms identical in appearance to *Theileria parva*, the causal organism of the disease. During a period of exactly one month following upon this discovery a total of six cases of similar infection in cattle was detected, but otherwise throughout the rest of the year no more cases were found in the 1,248 bovines examined *post-mortem*. During the 1923-24 season three undoubted cases of this kind of affection were detected, and rare Koch's bodies were believed to be found in the large mononuclear cells of a living animal that afterwards recovered. Of the six 1922-23 animals, five died within 5 to 17 days after infection with rinderpest virus, while one was a recently purchased bull that had not been used for any experimental work. The three 1923-24 animals were not affected with rinderpest; one was taken in for use in a blackquarter experiment, one had been discontinued for some time from a rinderpest test, and one was a calf containing a large admixture of European blood that died in an out-kraal. The lesions found *post-mortem* attributable to the peculiar piroplasm infection in the animals were, invariably, very striking enlargement of the spleen and usually of the lymphatic glands and infarcts of the kidneys, which, however, were few and ill-defined except in one case, and hence the gross pathological picture differed somewhat from that observable in the African disease. Transmission experiments, by direct inoculation of infected spleen pulp or by tick feeding, failed. Having in mind the pathological phenomena observable in the affection, the failure to transmit the disease experimentally, and the close resemblance of the piroplasms found within the red blood cells to those seen in the *Theileria mutans* infection, except that they were usually much richer and there was a tendency for the preponderance of one morphological type, it occurred to me that the infective agent of the condition that bore the resemblance to East Coast fever was not unlikely merely a highly exalted or virulent variant of the common *Theileria mutans*, which perhaps had gained special pathogenic properties in the body of a highly susceptible host. The work of Brumpt in Paris with an Algerian strain of *Theileria mutans* passaged through French cattle, that are normally free from infection with this parasite, afterwards came to my notice, and from his investigations it would appear that the *mutans* parasite can be exalted so as to produce an affection like East Coast fever, with the presence of plasmatic bodies in the lymphatic tissue.

The preparations containing the 'blue bodies' found in animals at Muktesar were shown to Sir Arnold Theiler during his visit to Muktesar in February 1924, and he declared that they were undoubtedly what he called *Theileria* bodies. The fact that in East and South Africa, East Coast fever breaks out with all the epizootiological characteristics of a disease caused by a parasite of highly fixed pathogenicity makes it difficult, however, to admit without considerable demur that the *parva* type of parasite is specifically identical with the *mutans* type. However, for further

reasons that will be published later in an extended technical paper we believe that there is no need to create a generic term other than *Theileria* to designate the *mutans* parasite.

Some observations and experimental work were performed in the laboratory upon suspected *Anaplasma* bodies in the blood of cattle; in the routine smears, 16 specimens in 1922-23, and 10 in 1923-24 were found to contain bodies identical in appearance with the structures held to be parasitic in nature that go by this name. However, we are not in a position to make any pronouncement on this subject at present.

Two cases only of infection with *Plasmodium bubalis* were discovered in this period in buffaloes.

Further, the subject was dealt with briefly in the following remarks upon piroplasmosis made in the Report of the Institute for the year ending March 1925 :—

Piroplasmosis. In the course of routine blood smear examinations at the laboratory the findings were :—(*i*) *Piroplasma bigeminum*, 189, (*ii*) *Theileria mutans*, 532, (*iii*) *Anaplasma*-like bodies, 5, (*iv*) *Nuttallia equi*, 9, (*v*) *Trypanosoma evansi*, 19, (*vi*) *T. himalayanum* (probably *T. theileri*) 1, (*vii*) Anthrax, 11, (*viii*) Hæmorrhagic septicæmia, 35, (*ix*) Microfilaria, 1, (*x*) Anæmic changes, 267, (*xi*) Leucocytosis, 9, (*xii*) Negative, 2,466.

It has been stated in the preceding Report that the common piroplasms discoverable in cattle in India are *Piroplasma bigeminum* and *Theileria mutans*. These piroplasms have a very widespread, but not universal (so far at least as concerns the former piroplasm), distribution in cattle in the country, and the risk of infecting susceptible cattle accidentally with piroplasms introduced with the virulent blood employed in the process of active immunization against rinderpest is a limiting factor of considerable importance in the success of the method and which necessitates special observation, with treatment by the injection of *trypanblau*, subsequent to the inoculation.

No case of the East Coast fever type of affection was seen in cattle during the year. The clinical history and results of blood examination reported from the field in the case of one valuable imported bull that succumbed to piroplasmosis a considerable time after rinderpest immunization makes it seem probable that infection with *Piroplasma argentinum* sometimes exists in this country. [Later experience, as has been already indicated, has failed to confirm the existence of *B. argentina* in India ; the field officer who was in charge of the case before its death reported large numbers of " small piroplasms " in the blood, and our present knowledge makes us strongly suspect that the fatality was due to a virulent *Theileria mutans* infection.]

In a blood smear received at the laboratory from a lamb that had succumbed in Madras a rich infection with *Theileria ovis* was demonstrable, with the presence of " blue bodies " in the large mononuclear leucocytes.

Our knowledge of *Theileria* infection in India is briefly summarized in the above excerpts, but further experience in the inoculation of cattle recently imported into India and the rapidly growing knowledge forthcoming from the work of researchers into the piroplasmoses of cattle in other countries compels us now to regard Theileriasis as a factor of the highest importance in the acclimatization of cattle to Indian conditions.

It may not be without interest to recall briefly what is known of piroplasms of the *Theileria* type. They were first recognized in South Africa by Koch in 1902 as the cause of the formidable tick-borne epizootic disease of cattle known as East Coast fever. In this disease the piroplasms—which are easily distinguished in the blood of affected animals from those of ordinary red-water by their small size and different shape, and the presence of several within a single blood cell in the acute infection—

are present in enormous numbers in the blood cells just before death. The infection, however, cannot be transmitted to a healthy beast by blood inoculation, but it can be transmitted by the inoculation of the macerated pulp of the spleen or lymphatic glands, especially in the earlier stages of the infection. The spleen and glands contain, in fact, certain characteristic stages in the development of the piroplasms known as "Koch's blue bodies." These bodies represent the earlier (schizogonous and gamogonous) stages in the development of the piroplasms within the body, and the minute structures observable before death in such large numbers in the blood cells are held to represent the later sexually differentiated male and female elements, which cannot propagate in the body of a new animal without conjugation, which, again, can only be accomplished in the stomach of certain species of ticks. These ticks are of the "dropping-off" kind; that is, they drop off on to the ground to moult after each stage in their life-history and seek a fresh host for the following stage. Thus, a tick which has fed in the larval stage upon an infected animal may transmit infection to a fresh beast in the following, nymphal stage; and a tick which has become infected as a nymph may transmit disease to an animal upon which it feeds as an adult. The infection is not transmitted hereditarily through the eggs, as in the case of *B. bigemina* infection. To eradicate the disease set up by this infection by tick extermination it is therefore necessary to dip cattle in infected areas every three to five days—namely, at intervals not exceeding the period of attachment of any single stage in the life-history of the tick—and eradication of the scourge by this means has been successfully accomplished over wide areas in Southern and Eastern Africa.

In 1906, Theiler noted that cattle generally in South Africa harboured in small numbers in their blood minute parasites which appeared to be quite harmless to the indigenous cattle and which bore a close resemblance to the blood forms of the *parva* parasite. These harmless parasites he designated as *Piroplasma* (now *Theileria*) *mutans*. They were not altogether harmless, it seemed, however, towards imported cattle, for they set up in these animals a rather mild febrile disease after a distinctly more prolonged period of incubation than that observed after inoculation with *B. bigemina*. Further, the *mutans* infection could be transmitted by direct blood inoculation, no "blue bodies" were seen after infection, and the animals remained susceptible to the *parva* infection.

A curious and, in our opinion, fundamental observation in this connection was reported in 1904 by the two Russian observers, Dschunkowsky and Luhs, of the anti-rinderpest serum institute of Surnabad in the Trans-Caucasus. These workers were undoubtedly dealing with a mixed infection, due to *B. bigemina*, and probably also to the small piroplasm-like body known as *Anaplasma marginale* (concerning the importance of which we have been unable to obtain definite proof in India). Some of the animals they had under observation at their institute succumbed to massive infection with a minute piroplasm designated *Theileria annulata*; the affection could not be transmitted by blood inoculation to the locally bred

cattle, but a febrile disease was transmitted, following on an incubation period of 10 to 25 days, to imported cattle after injection with massive quantities of blood from affected animals; some of these animals succumbed, and it was later found that "blue bodies" were discoverable in the lymphatic tissue of these animals identical with those seen in East Coast fever. A sporadic affection was therefore established with nearly all the features of East Coast fever except epizooticity.

The Italian worker, Carpano, in 1915, reported affection of the same kind, but which he believed to be sporadic infection with *T. parva*, in the Italian colony of Eritrea, and he ascribed cases of so-called Mediterranean Coast fever to infection of this kind.

The French authority Brumpt later, in 1923, reported the results of a series of experiments in which he seems to have shown that repeated passage of an Algerian strain of *Theileria mutans* through clean French cattle brought about the exaltation of the parasite at least to the status of the Russian workers' *T. annulata*.

At about the same time, a series of very important communications bearing upon this type of infection as the cause of disease along the Mediterranean littoral and neighbouring territories was forthcoming, detailed reference to which would be beyond the scope of this paper. [Mason (1922) and Doyle (1924) in Egypt; Knowles in the Soudan; Ed. Sergent and his collaborators (1924) in Algeria; Velu (1923) and, also, Van Saceghem (1925) in the Belgian Congo in Morocco; Schern (1919) in Asia Minor.][1] From this work, it seems to be confirmed that the common recurrent fever of cattle along the Mediterranean Coast, known in Egypt and the Soudan as Egyptian fever, is a Theileriasis, caused by infection either with a virulent type of the *mutans* parasite or due to a specially high susceptibility of the cattle, particularly noticeable in imported cattle, towards infection with this parasite; in the more severe cases of infection "blue bodies" are found in the lymphatic tissue. From the work of Brumpt it may also be reasonably inferred that the *annulata* type is merely a virulent variant of the widespread *mutans* type. Out of 24 French and British cattle through which what he originally believed to be *mutans* parasites, of Tunisian origin, were passaged either in Paris by him or in England by Stockman, Brumpt states that five succumbed, after more or less considerable intervals, to pernicious relapses of infection (namely, one, at the second passage, after 4 months; one, at the third passage, after 7½ months; one, at the fourth passage, after 7 months; two, at the fifth passage, after 3½ and 5 months, respectively).

The type of infection set up by *T. mutans* (or, what we presume to be merely a virulent variant, *T. annulata*) is thus very different from that seen in the epizootic disease known as East Coast fever, caused by *T. parva*. After infection, the parasites persist in the blood probably indefinitely, and the balance between the multiplication of the parasites and the restraining influence of the tissues may be upset

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[1] See Brumpt. Les Piroplasmes des bovidés. I—Les Theilériés. *Annales de Parasitologie humaine et comparée*, 1924, Vol. II, p. 340.

to the detriment of the host, even without intercurrent infection, at any time subsequently.

In *T. parva* infection there is complete sterilization of the tissues when there is recovery from affection and the animal is subsequently immune towards subsequent infection with the parasite. Ed. Sergent and his colleagues have reported what they consider to be a common type of *Theileria* parasite among Algerian cattle which they designate *T. dispar*. This type undergoes the same kind of cyclical evolution in the bodies of infected animals as does *T. parva*, with a definitive sterilization after recovery. It causes widespread sporadic cases of fever among cattle in Algeria during the hot season (July August). The disease is transmissible by blood inoculation, when this fluid contains " blue bodies " (in the mononuclear leucocytes).

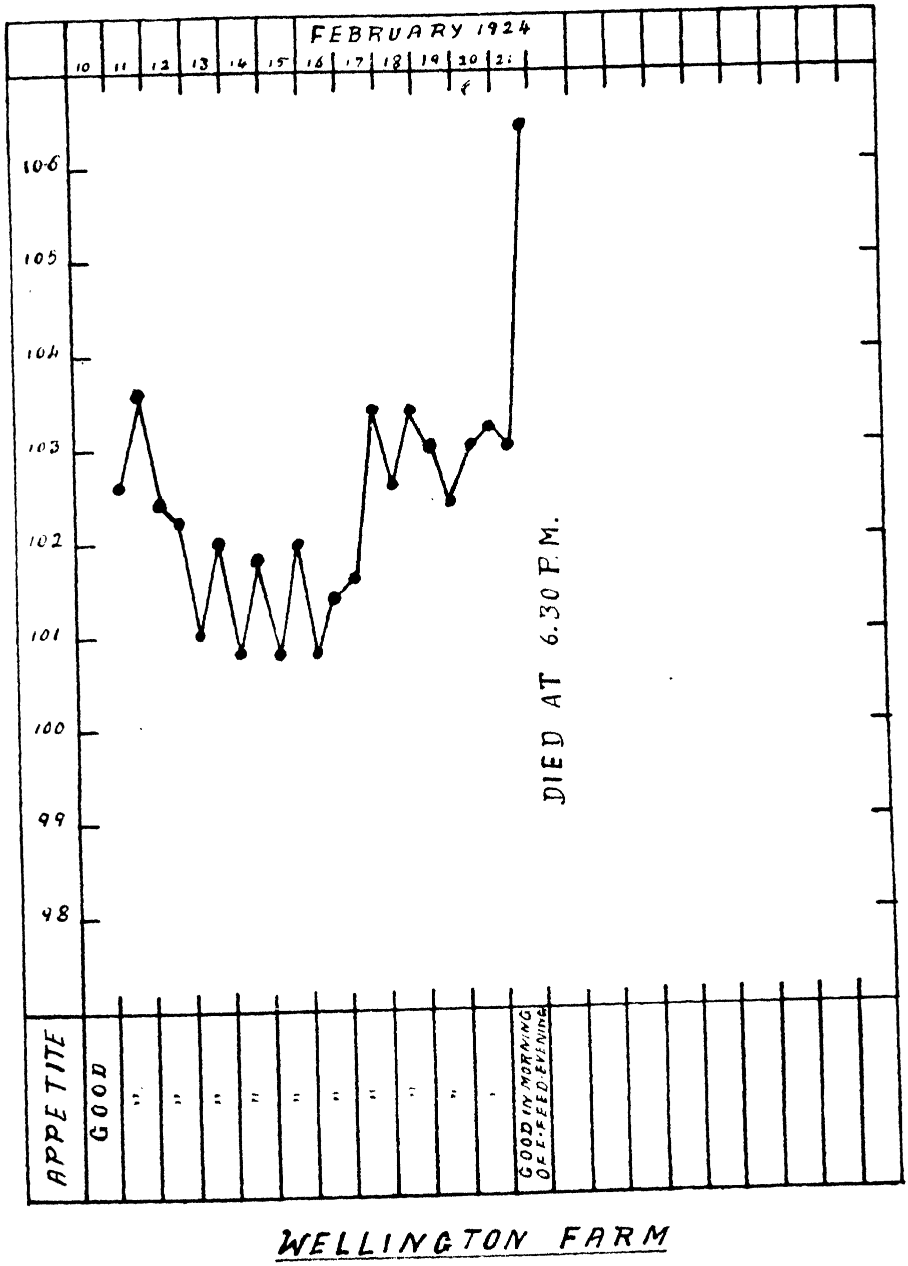
Brumpt summarizes the knowledge we have upon the relationship of the various reported species of *Theileria* in cattle as follows :—The four species of *Theileria* which we recognize, more or less provisionally, are difficult to differentiate morphologically, but they present certain biological characteristics which indicate a series of very curious adaptations, that must have been evolved in the course of time as the result of certain influences which are totally unknown. The ancestral parasite, belonging perhaps to the *mutans* type, which is of inappreciable or very low pathogenicity, may have become *T. annulata*, which is sometimes pathogenic, but does not set up a cyclical disease ; the latter type may have engendered the new species, *T. dispar*, which sets up a cyclical disease that is often fatal, but is yet inoculable, and confers a definitive immunity. As a last type, we would thus have *T. parva*, which can be distinguished from the last mentioned type by the fact that it cannot be transmitted by blood inoculation. It is true, however, that one could argue that these adaptations might have been accomplished in the inverse sense.

Our experience in India has convinced us (*i*) that the *Theileria* type of piroplasm, which we have hitherto designated simply as *T. mutans*, is of universal distribution ; (*ii*) that, usually, it causes no visible ill-effects in indigenous cattle, even when these animals are depressed by intercurrent infection with rinderpest ; (*iii*) that, very rarely, for some reasons entirely unknown, it may become resuscitated in virulence in indigenous animals, to set up the serious type of infection of the kind described as due to *T. annulata* by other authors; (iv) that, not infrequently, in recently imported cattle, subjected to the serum-simultaneous inoculation against rinderpest, it may set up a severe, fatal infection. We may presume, with good reason, that what takes place after the inoculation would otherwise ensue naturally, by the bites of infected ticks (probably *Hyalomma œgyptium* in India). The period of incubation for *mutans* infection has been stated to extend from 12 to 40 days. From the recent work of Brumpt, however, it seems that an animal may succumb several months after infection without showing in the meantime distinct signs of ill-health. The *Theileria* affection can be readily distinguished from that caused by *B. bigemina* by the fact that there is no red-water, and usually little anæmia, although in some cases there

CHART I.

IMPORTED AYRSHIRE BULL (ENGLISH) ; AGE 2 YEARS.

Serum-simultaneous anti-rinderpest inoculation given on 10-2-1924.

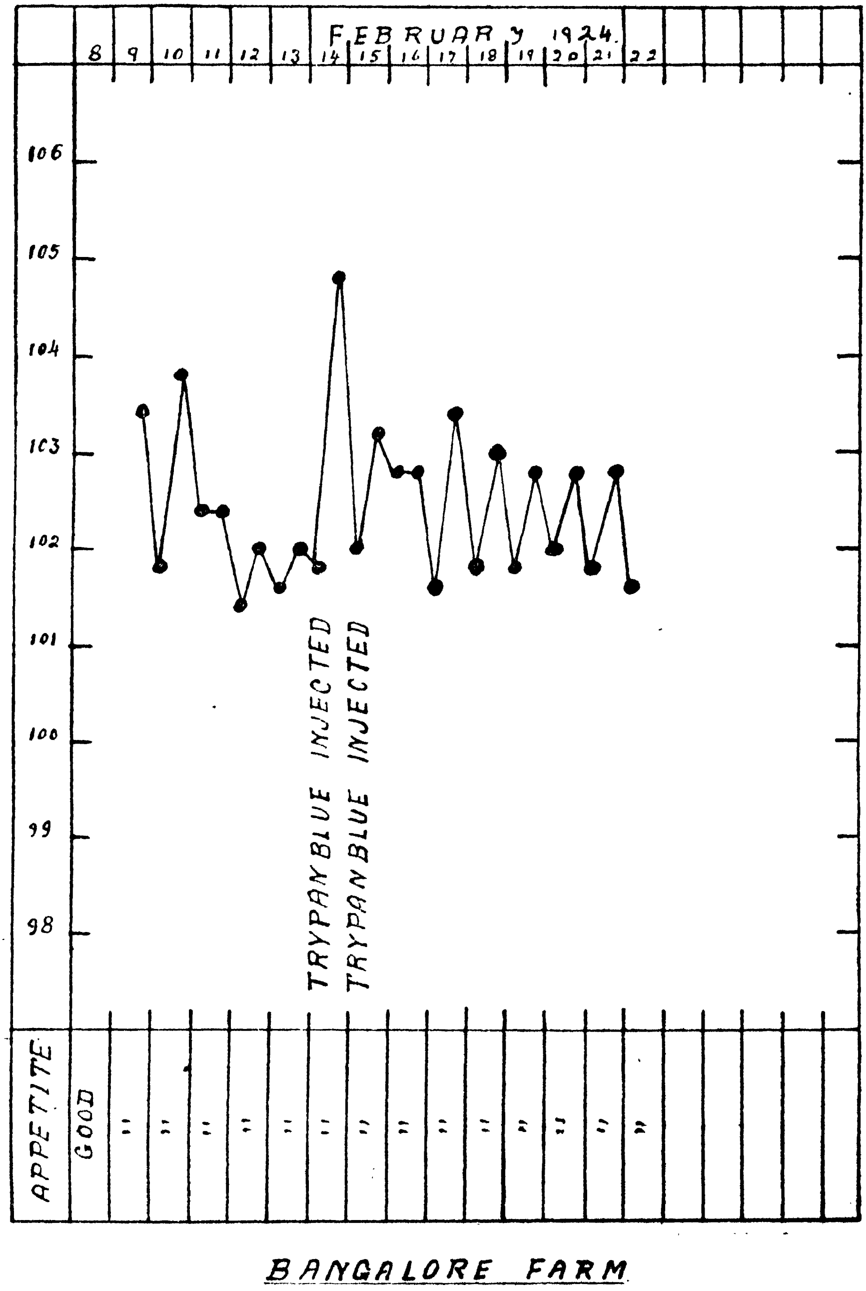


Showing sudden death in an imported Ayrshire bull, due to *Babesia bigemina* infection, 11 days after inoculation with the first dose of virulent blood in the serum-simultaneous inoculation against rinderpest.

CHART II.

IMPORTED JERSEY COW (ENGLISH); AGE 3 YEARS.

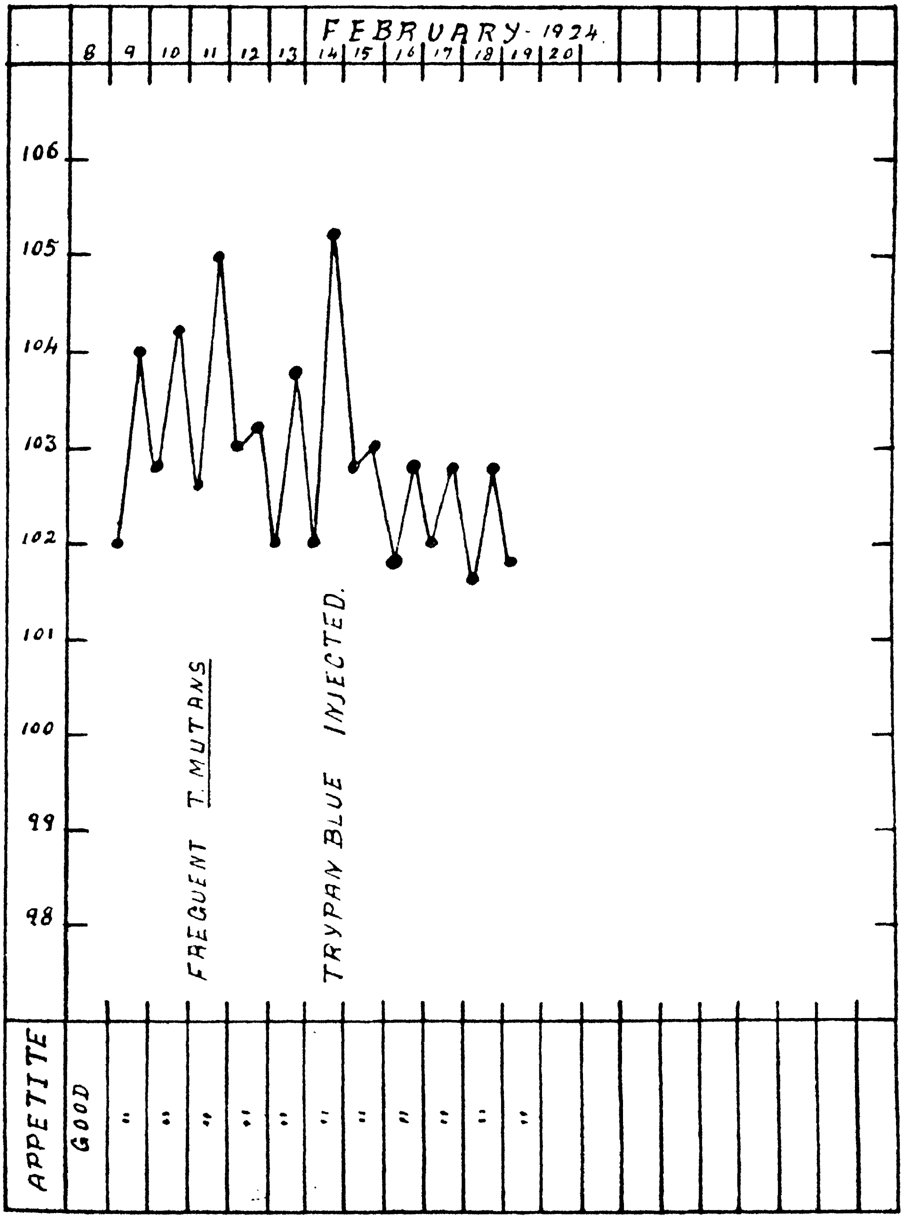
Serum-simultaneous anti-rinderpest inoculation given on 8-2-1924.



Showing a sudden marked thermal reaction on 6th day after inoculation, due to *B. bigemina* infection, and the curative effects of timely injections of trypanblue, in an imported Jersey cow

IMPORTED HOLSTEIN BULL (AMERICAN); AGE 2 YEARS.

Serum-simultaneous anti-rinderpest inoculation given on 8-2-1924.



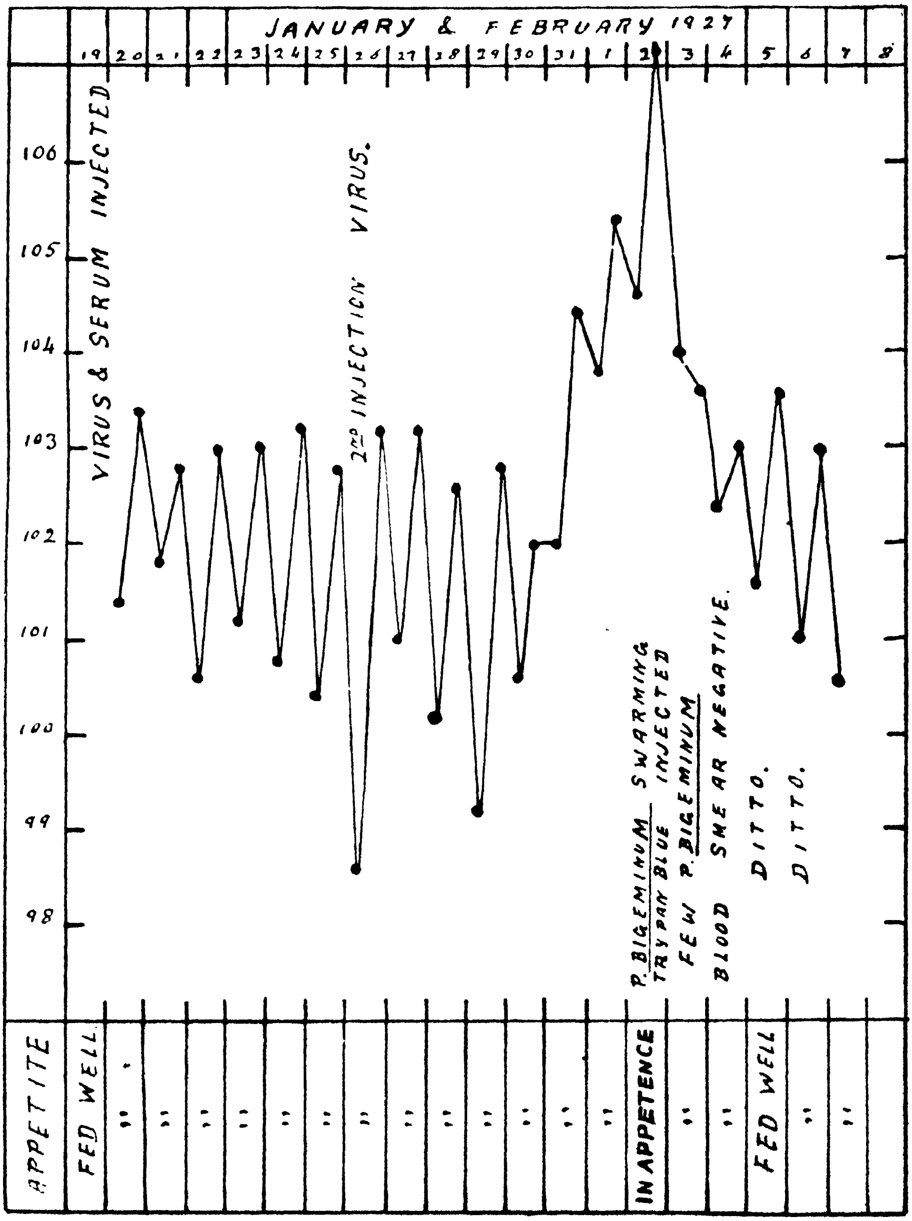
BANGALORE FARM.

Another chart showing the same kind of history as Chart II. In this animal *Theileria mutans* were numerous in the blood 3 days after inoculation; it is not improbable that the animal was already infected with these piroplasms at the time of inoculation.

CHART IV.

MONTGOMERY BREED BULL-CALF (ALLAHABAD).

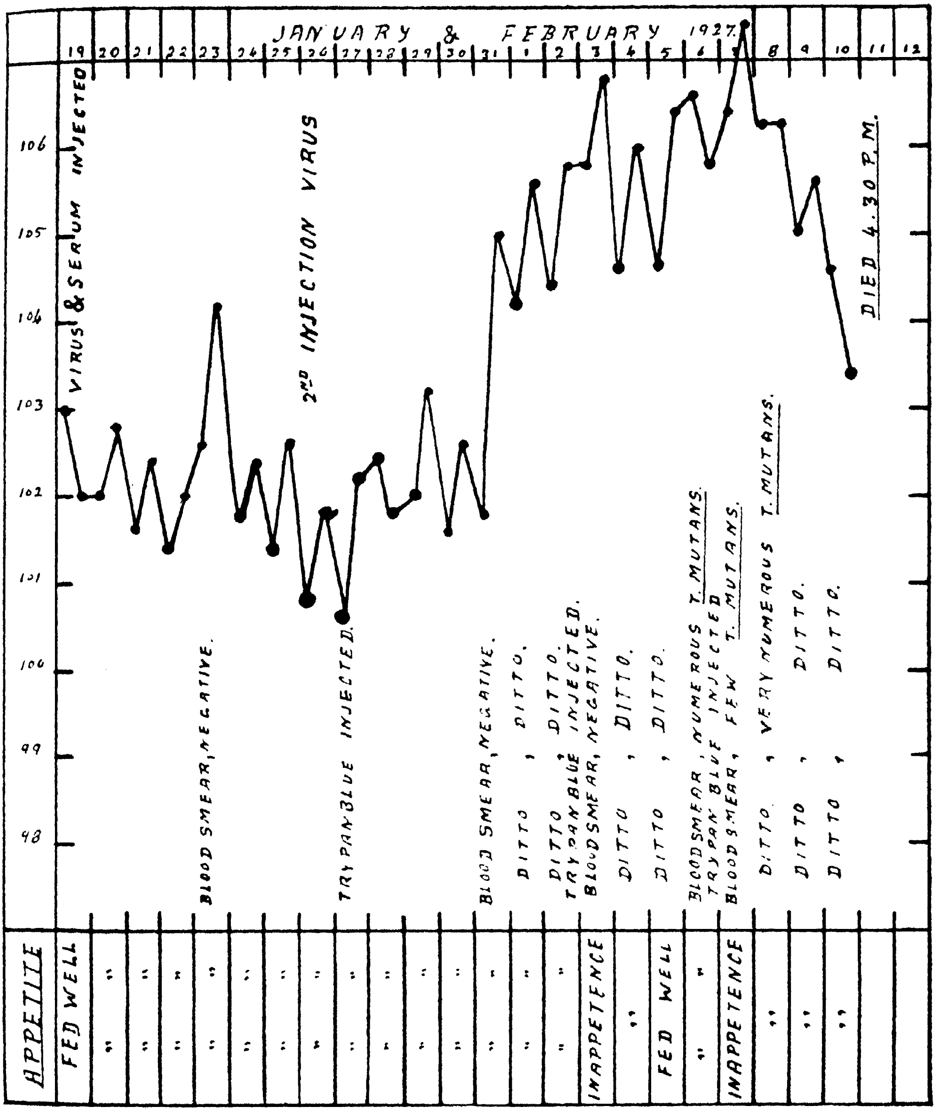
Serum-simultaneous anti-rinderpest inoculation given on 19-1-1927.



Showing a somewhat severe reaction in an indigenous calf (Montgomery breed) after the serum-simultaneous inoculation against rinderpest. The temperature reached 107·2°F. on the 7th day after the second inoculation with virulent blood (which most probably conveyed the infection), or on the 14th day after the first injection. *B. bigemina* was very numerous in the blood at this time, see Pl. XXXVIII, figs. 1A and 1B). Note the rapid drop in temperature after the injection of trypanblue.

IMPORTED JERSEY BULL (ALLAHABAD).

Serum-simultaneous anti-rinderpest inoculation given on 19-1-1927.



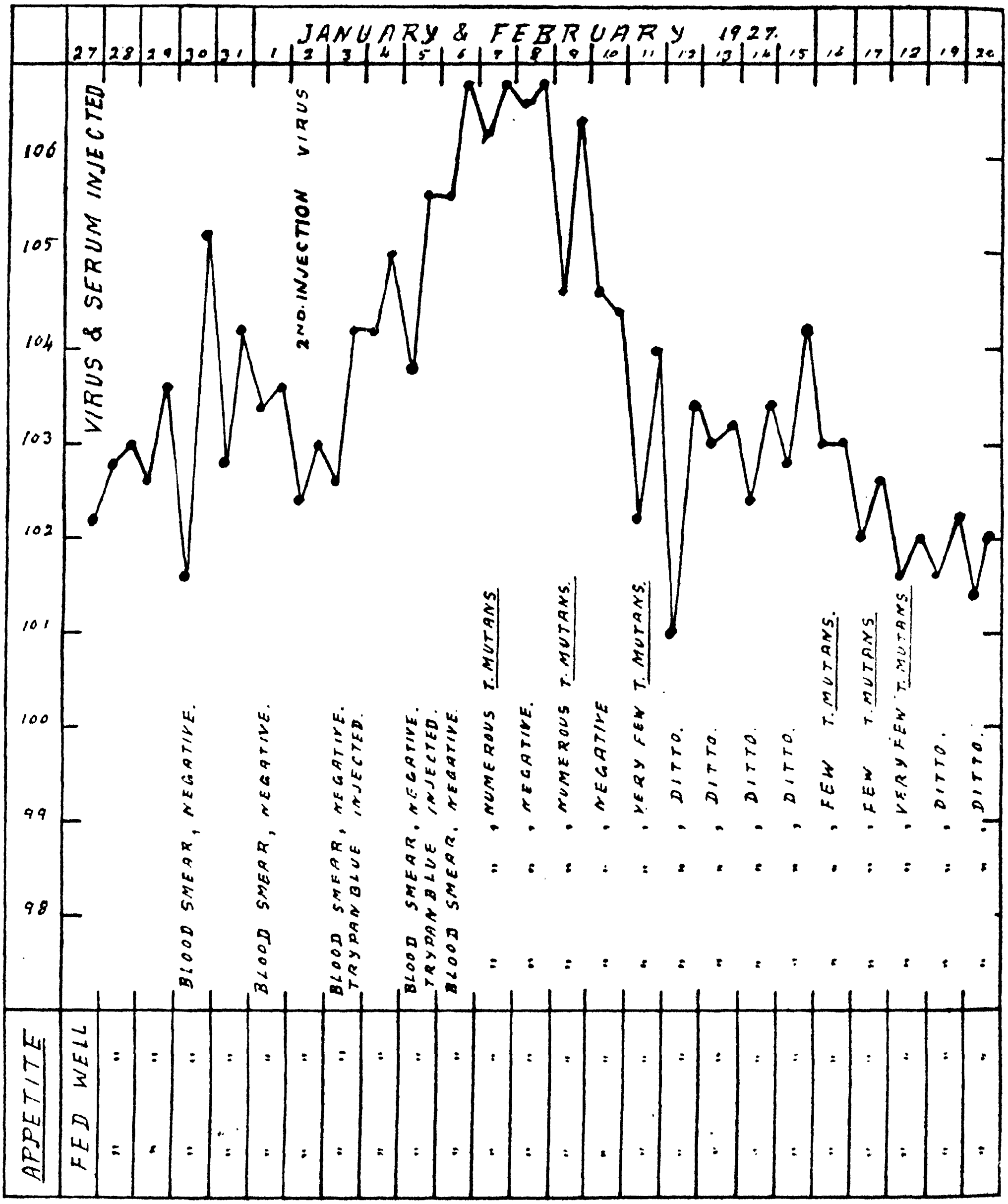
Showing a fatal virulent infection with *Theileria mutans* in an imported (American) Jersey bull, after the serum-simultaneous inoculation against rinderpest. Note that the first rise of temperature takes place on the 12th day after the first injection of virulent blood, or on the 5th day after the second injection. *T. mutans* first appeared in the blood in considerable numbers, on the 7th day of fever. Trypanblue had no effect on the fever. The animal died on the 11th day of fever. Blood smears showed very numerous *T. mutans*, with the presence of "Koch's blue bodies" in the large mononuclear leucocytes (see Pl. XXXVIII, fig. 2).

The *post-mortem* findings, reported by Mr. Menon, briefly summarized, were :—Condition fair; blood "watery;" internal organs contain petechiæ; marked icterus of mucous membranes and liver; great enlargement of spleen and liver; appreciable enlargement of lymphatic glands; consistence of spleen and liver much reduced.

CHART VI.

IMPORTED HOLSTEIN BULL (ALLAHABAD).

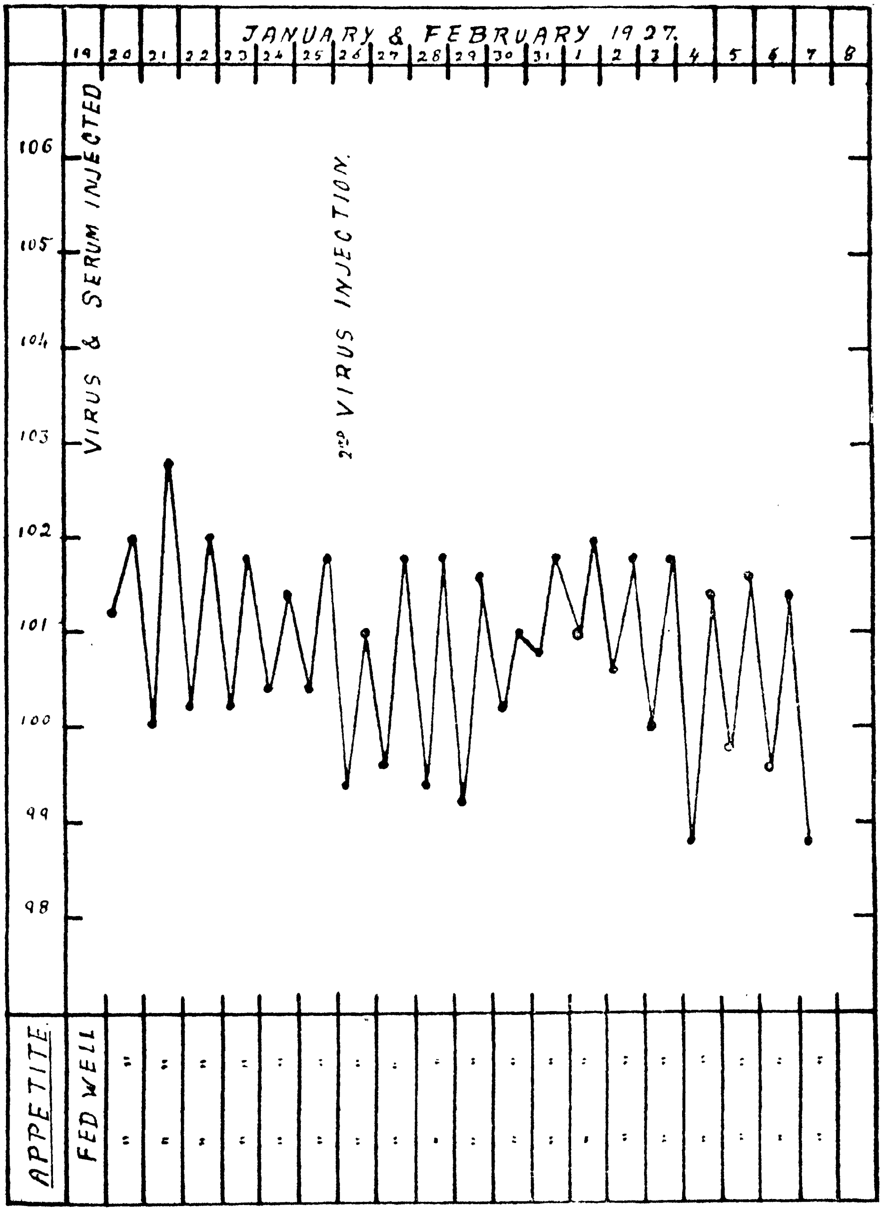
Serum-simultaneous anti-rinderpest inoculation given on 27-1-1927.



Showing acute infection with *T. mutans* following upon the serum-simultaneous inoculation in an imported (American) Holstein bull, on the same establishment as the animal the history of which is depicted in Chart V. The animal relapsed again, after the drafting of the chart, to *T. mutans* infection, and was treated tentatively with intravenous injections of Bayer 205. (Both these recently imported American bulls were already heavily infected with ticks, apparently *Hyalomma ægyptum*, at the time of inoculation.) [The animal was subsequently reported to have made a good recovery.]

MONTGOMERY BREED COW (ALLAHABAD).

Serum-simultaneous anti-rinderpest inoculation given on 19-1-1927.

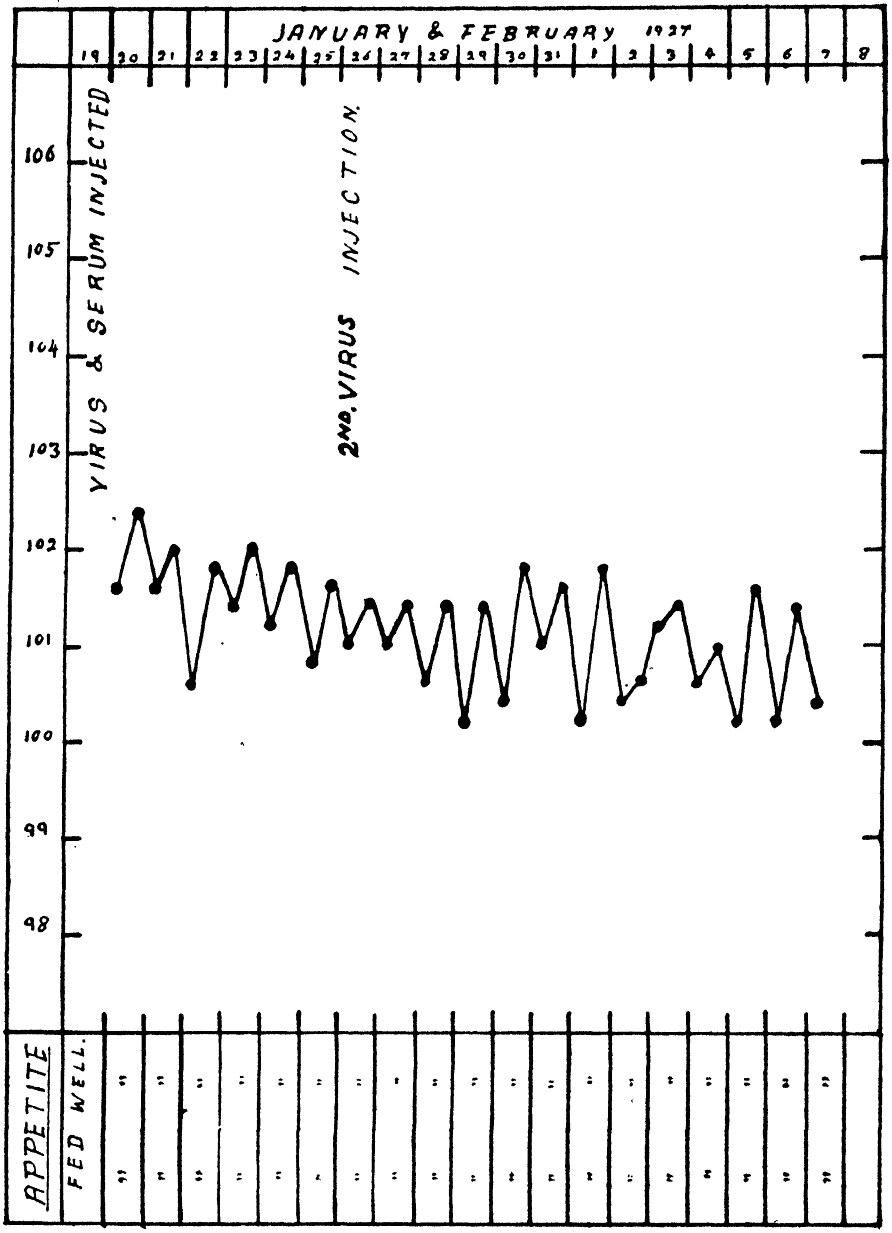


Showing the history of an indigenous cow subjected to the serum-simultaneous inoculation on the establishment to which belonged the two imported animals depicted in Charts V and VI. Note that the virulent blood produced in this animal no reaction traceable to the contamination with *T. mutans*.

CHART VIII.

MONTGOMERY BREED COW (ALLAHABAD).

Serum-simultaneous anti-rinderpest inoculation given on 19-1-1927.



Showing the history of an indigenous cow subjected to the serum-simultaneous inoculation on the establishment to which belonged the two imported animals depicted in Charts V and VI. Note that the virulent blood produced in this animal no reaction traceable to the contamination with *T. mutans.*

may be fairly well marked jaundice. *Trypanblau* is ineffectual in treatment; likewise, arsenical compounds seem to exert no influence on the infection.

We may pass by in this paper the very prevalent infection caused by the protozoan parasites known as coccidia in the bowels of cattle in India—usually of no significance, except when the animals are depressed by an intercurrent infection with rinderpest, the occasional outbreaks of surra in cattle caused by exaltation of the trypanosomes from their ordinary, commensal state in these animals; and also the economically most important infections determined by invasion with worm parasites. It is believed that sufficient evidence has been adduced to explain the main factors in the acclimatization of imported cattle.

A practical consideration of the phenomenon, however, suggests two or three important questions:—

(i) Can livestock imported from Western countries be effectively acclimatized to Indian conditions?

(ii) If so, how can we best safeguard imported stock, by artificial means, if such are available, against the risks of acclimatization?

(iii) Is it economically sound, in the ultimate resort, to attempt improvement of the indigenous stock by infusion of imported blood that is not acclimatized, or is it better to undertake improvement of the indigenous stock, by means now well known to the livestock expert, to secure ultimately the same result?

(*i*) The experience of other countries tends to show that acclimatization can be accomplished more or less successfully. Most of the newer great stock-raising countries mentioned in this paper, such as South America, South Africa, the Southern States of United States of America, and Australia (with particularly the example of Queensland in mind) prosecute cattle breeding with the most renowned European breeds. The analogies of these countries are, however, not quite complete; to be complete, one must seek the experience of countries in which the potentially pathogenic parasitic fauna (or flora) resemble closely those known to exist in India. Thus, the experience of Egypt and the other African countries along the Mediterranean littoral may guide us best in this respect and this experience indicates that the problem of acclimatization presents considerable difficulty. A great deal more has to be learnt, however, by trial in India before we can issue categoric statements upon what is likely to be the ultimate issue, particularly as to what might happen if imported cattle were distributed in a widespread manner throughout India.

ii) Imported cattle can be protected against the prevalent Indian plagues, such as rinderpest and hæmorrhagic septicæmia, with no great

difficulty. With greater difficulty, they can be protected against red-water (tick-fever, Texas fever). We have no means at hand at the present time to protect them against piroplasmosis of the *Theileria* type. It is not anticipated that there will be much technical difficulty in rendering the serum-simultaneous inoculation against rinderpest free from risk due to piroplasm complications.* (In the laboratory, this has been shown to be possible by using as the source of virus, blood from rabbits or sheep in which rinderpest has been artificially established; the piroplasms are highly specific, and so there would be no danger from them by using the blood from another species of animal.) For general purposes, however, it has not hitherto been considered worthwhile to use "cleaned" virus of this kind. On the whole, the younger the animal is when it is imported, the more likely it is to withstand the risks of acclimatization.

(*iii*) The third question is one of supreme importance. If, as we believe to be possible from the present-day developments in systems of breeding, indigenous cattle can be improved, even though the process may prove somewhat tedious and often disappointing, to secure the same results as can be obtained with a fair degree of certainty and quickly from the first cross with imported blood, measures to attain this end should certainly be preferred, in the light of the known obstacles confronting satisfactory acclimatization of imported cattle.

Explanation of Plate XXXVIII.

Plate XXXVIII, Figs. 1*A* and 1*B*.—Microphotographs of the blood of the Allahabad calf depicted in Chart IV, showing the presence of numerous *Babesia bigemina* in the red blood cells. (This result appears to indicate that the subjects of Charts V to VIII, which were inoculated with the same blood, were immune to the *bigemina* infection: the American animals had therefore probably already contracted "Texas fever" prior to their export from America, unless it is assumed that the anticipatory injections of trypanblue given to these two animals completely forestalled a febrile reaction.) Fig. 1B shows the outline of the parasite within the blood cells rather more clearly than does Fig. 1A, but their internal structure has not been displayed.

Plate XXXVIII, Fig. 2.—Microphotograph of the blood of the Jersey bull depicted in Chart V, showing the presence of very numerous *Theileria mutans* in the red blood cells, and a "Koch's blue body" in a large mononuclear leucocyte (k).

(The three preparations are stained by Leishman's stain.)

*Since the original draft of this paper was submitted for publication, in February last, we have now obtained a "virus," which is piroplasm-free as regards cattle, by "fixing" rinderpest upon goats in the laboratory. Steps are now taken to distribute this virus for the serum-simultaneous inoculation of cattle throughout India.—[J. T E. October 1927.]

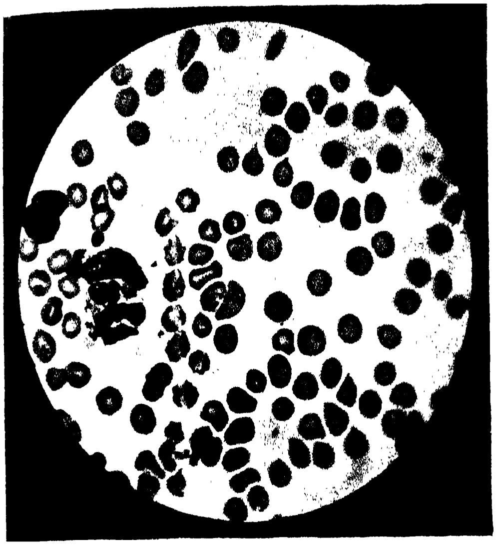


Fig. 1A (×750).

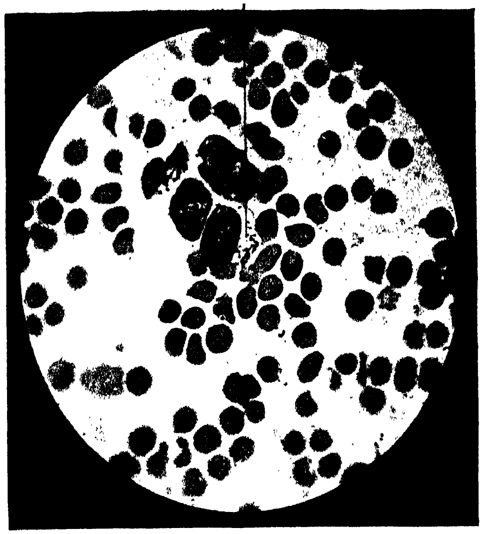


Fig. 2 (×750).

Fig. 1B (×800).

AGRICULTURAL IMPLEMENTS SUITABLE FOR THE USE OF THE INDIAN CULTIVATOR.

BY

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Deputy Director of Agriculture, Western North Bihar Range.

(Continued from Vol. XXII, Pt. V.)

The Bihar Cultivator.

In considering types of cultivators which may suit the needs of the ryot we must try to reconcile the disabilities and limitations already discussed, with the needs of the work to be done.

Cheapness is probably the primary essential. For all round work the spring tined cultivator is almost certainly the best implement yet produced ; but it is too expensive for our purpose, partly because the springs themselves cost so much, and partly because they can only be mounted in a rather expensive frame. So we must be content with rigid tine mountings. Secondly, any form of apparatus for widening or narrowing the frame is an additional expense and a source of trouble in upkeep. Its sole purpose is to adjust the width of the implement to that of the rows between which it will work ; but as the ryot has generally still to learn to sow his crops in rows and always tends to sow more closely than necessary, the sound policy will be to give him a cultivator that will till the land thoroughly and that his cattle can draw, and then teach him to sow his crops in rows of a width suitable to his cultivator. He will be quite happy to be allowed to sow his crops rather too closely for a few more generations. We can therefore economize a little more by doing away with any expansion apparatus and making our cultivator of a fixed width. Thirdly, let us cut out the wheel. These are costly to make and they wear rapidly in this dusty air ; in fact the better they are oiled the quicker they wear. It is doubtful if in the complete implement we can combine strength sufficient to stand up to the various conditions of work encountered, with lightness sufficient to enable it to be easily carried about. The weight can be cut to about 20 seers but will generally be about 30, so that, although the ryot really does understand carrying, he will quickly agree on the advantages of letting his cattle drag the implement backwards and forwards to work. We should therefore incorporate the simplest, cheapest skid that can be devised.

The cultivator must be suited to bullock draft and small fields. Two considerations are entailed, *viz.*—(*a*) Its frame must be rigidly fixed below the rear end of a pole, sloping from the driver's feet to the centre of the yoke, so that the implement will be between the hind quarters of the bullocks. If the pole is too steep and the cultivator too far forward between the bullocks, she will bump and not penetrate easily into hard ground. If the pole is too flat and the implement too far behind the bullocks, the driver cannot control the latter and the turning room required is too great. The ideal slope for the pole seems to be about 2 to 5 or, for very small bullocks, 1 to 3. (*b*) The bulk of the cattle used by ryots can only draw three tines, though I find they can comfortably manage this. So the cheapest, simplest, implement should carry three tines only ; though for certain tracts where bullocks are larger, for Government farms, sugar factories, etc., five tined cultivators would be required, and it may be advisable to sell a type readily convertible from one to the other.

The need for such simplicity as will allow the village carpenter to fit the pole and handle, and the ryot himself to change the position of the tines, is almost as important as cheapness ; but, unfortunately, the two seem mutually contradictory. For absolute simplicity of fitting and operation, bolts and nuts should be entirely omitted, and the various parts should fit, and be wedged, into specially prepared slots on the frame. But this preparation of the slots adds decidedly to the cost of the frame and there is also the chance of wedges and other small parts being lost. The cultivator's child has not many toys and trouble may arise when, on wanting to use his implement, the ryot finds that his son has borrowed the wedges and pins to play tip cat, or his daughter discovered their value as clothing. On the other hand the duplication of important parts of the frame involved in slotting enables the size of metal to be reduced appreciably ; while really good fit in the slots would reduce the strain on wedges or pins so much, that any sort of peg, *e.g.*, bamboo, would function.

I find it impossible to say definitely which is the weightier of these two considerations, and doubt if the matter can be finally settled, except by putting on the market sufficient of each type to determine the exact difference in cost, and which the ryot will more readily take to. But it should be simple enough to make one type easily convertible to the other, so that the ones that do not find favour, need not be a loss to any one.

From the limitations let us pass to the essentials. We know that the ryot can do most things with his country plough, except shave with it. So we must provide for all the known cultivation operations and trust that the worn out tines may become fashionable as super Gillette razor blades. Different kinds of work require different relative settings of the tines, and the ones that have been thoroughly explored are detailed below.

(1) *Breaking land after harvest.* There will be stubble and weeds and the earth will come up in clods, all tending to block the tines. Figures

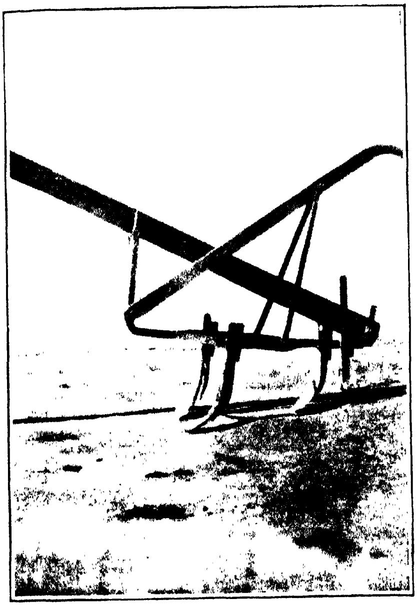

Fig. 1. The Bihar 3-tined cultivator.

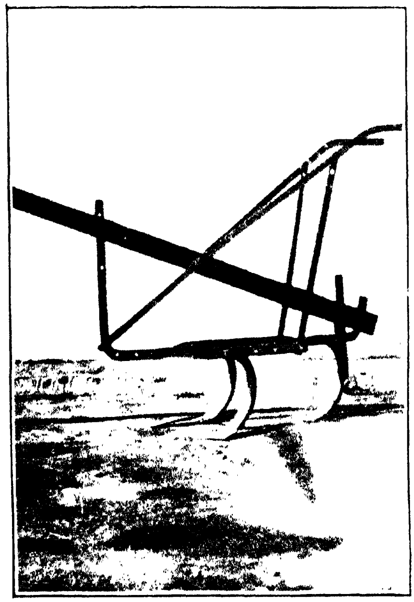

Fig. 2. The Bihar 3/5-tined cultivator.

Figs. 3 and 4. The Bihar 3/5-tined cultivator working in maize rows. It will be noticed that the driver is within easy reach of his bullocks and that the turning room required is little more than the length of the cattle.

1*a* and *b* show the best settings of these for this work as the general wedge shape reduces blocking by tending to push rubbish and clods outwards, while the uneven setting of the side tines also helps to let rubbish through.

(2) *Working in soft land where weeds are few*, but it is important to break soft clods and root out what weeds there are, and also intercultivating crops, require the central tine behind. Fig. 1*c* is better if there is much rubbish and *d* better if no rubbish but it is important to root out all small weeds.

(3) By fitting a bamboo spout behind the front central tine and feeding seed through the former into the furrow formed by the latter, to be covered by the 2 side tines following at a distance of 15″, maize, *rahar* (pigeon-pea), cotton, etc., can be sown in one operation.

(4) By having the central tine 15″ behind the side ones and feeding seed through duplicate spouts behind the latter, *rabi* grain crops can be properly sown and covered in one operation, with the consequent saving of labour and, what is more important, moisture. For sowing work a distance of 15″ from front setting to rear ones is essential. For general work *a* or *c* is best according as to whether or not there is trash or stubble. For intercultivation *c* or *d* are required.

From numerous trials in the land and from measurements of existing implements it is thought that a lateral width of 5″ from tine to tine is about the best for most work. The ryots' bullocks can handle three tines of 2 to 2½ inches width each ; and if these are set 5″ apart laterally, cultivation is fairly thorough and yet earth can get through ; and, with the fore and aft settings noted above, blocking is reduced to a minimum. The width of the strip of earth cultivated at each passage of the implement is 18 to 24 inches according to the depth at which the tines are set ; and intercultivation can be done between rows as close as 2 feet, and as wide as 2 ft. 6 inches, very suitable distances apart for maize, etc. To get down to the 18″ potato furrow one would have to take off one tine.

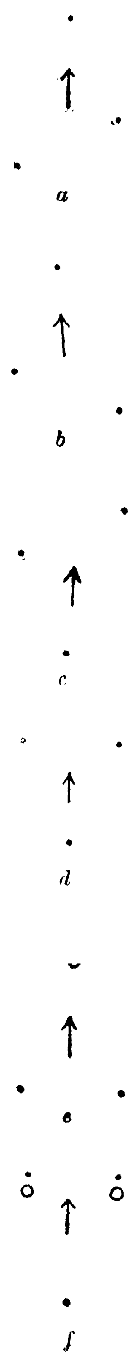

Fig. 1

To give this width and the above described fore and aft choice of tine positions in a three-tined cultivator, there would need to be 6 possible points of attachment for the tines as shown below. (Fig. 2.)

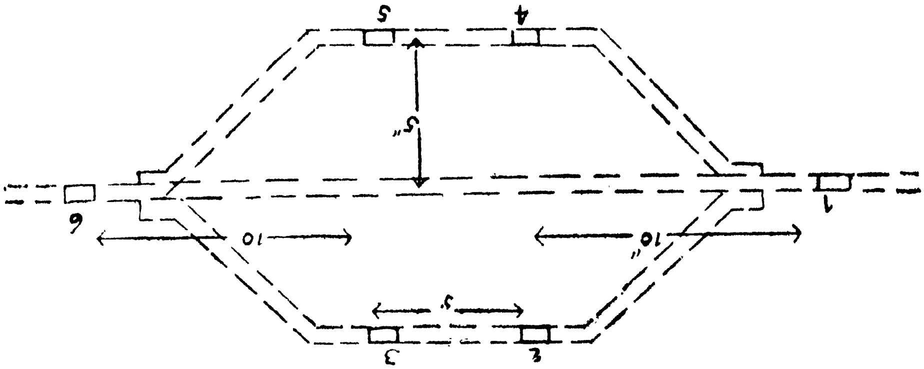

Fig. 2.

The dotted lines indicate in horizontal section the simplest form of frame which will give these positions.

For work, this frame must be rigidly fixed below the rear end of the sloping pole as already noted, and there must also be either one or two handles. One handle is cheaper than two, the ryot is accustomed to use one only, and for ordinary " chas " ing one is quite satisfactory. But when cultivating between crops in rows, as in ridging work, the driver cannot walk alongside his machine but must walk behind ; and from there control with only one handle is very difficult, and 2 handles are almost essential. As I think the ryot will learn by experience the value of two handles, it would be wise to design the frame to take one or two as required.

For skid there is probably nothing simpler or cheaper than a plain $1\frac{1}{4}'' \times \frac{3}{8}''$ flat bar, sliding vertically up and down in a slot in the centre member of the frame, and with its lower end twisted and bent at right angles to give a flat sole, below which an extra wearing piece can be rivetted or bolted. A wedge or pin can be used to fix the skid at the right height. We must allow room on the frame for the skid to be fitted at the rear end, as, if placed in the middle of the frame, it increases the tendency to blocking, while if at the front, it is difficult to get at for adjustment and carries more than the weight of the machine. At the rear, it is readily accessible without deserting the helm, it carries less than the weight of the machine and it requires less vertical movement, as, after dropping it a few inches, the tines can be lifted clear of the ground by bringing the yoke back along the pole.

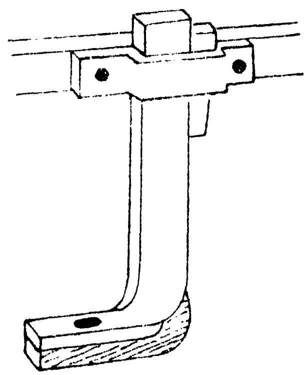

Fig. 3.

As far as I know, shanks—pieces connecting the points to the frame—are never made smaller than $1\frac{1}{4}'' \times \frac{3}{8}''$ section.* On the lightest American 1 horse machine they are of that size and, though some of $1'' \times \frac{1}{4}''$ are being tested, and seem to stand so far, they have not been in use under severe conditions long enough to justify a definite recommendation.

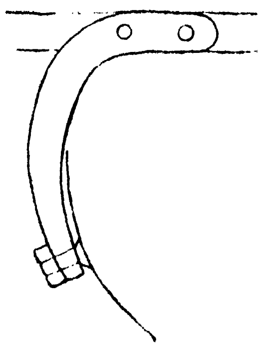

Fig. 4

If bolts and nuts are to be used, the simplest cheapest form is a curved $1\frac{1}{4}'' \times \frac{3}{8}''$ bar, with the lower end fitting the curve of the tine and splayed sufficiently to take a $\frac{3}{8}''$ hole through which the bolt fixing the tine to the shank passes. The upper portion curves over to lie flat alongside the frame to which it is bolted by 2 bolts $2\frac{1}{2}''$ apart. But if it is desired to do away with bolts and nuts the same sized bar can be used but the upper portion remains straight and passes through a vertical slot in the frame, being fixed in position by a wedge or pin. The lower portion would as before curve to fit the tine, but the latter would be fitted with a stirrup back which would slide on to the end of the shank, tapered to receive it, and be held by a pin or bent nail.

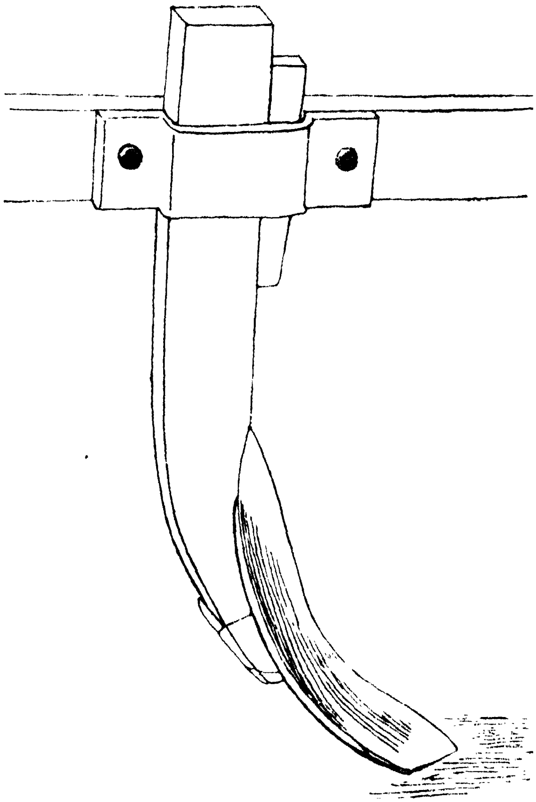

Fig. 5.

If slots are to be used, they might be separate small castings slipped on to the frame at the time of assembly, and in this case could be made such a close fit that simple pins could be used to hold tines or skid in position. Or, and

*It has since been definitely decided that shanks of $1'' \times \frac{1}{4}''$ section are not sufficiently stiff.

probably preferably, they might be made by rivetting on to the frame extra pieces thus :—

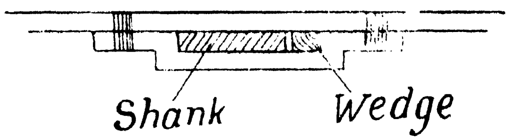

Fig. 6.

and then using a wedge to fix the tine or skid in position. It should be noted that if slots are used the frame can be made symmetrical and the spacings set out in earlier paragraphs be adhered to ; while if the bolt fixed, a curved shank is used ; the curve of the shank behind the bolt holes requires 2″ more space than is needed in front, and this makes it necessary to compromise our spacing somewhat. The asymmetry so introduced is not sufficient to affect seriously the work of the implement, but it needs to be allowed for in the frame.

For many years at any rate, we cannot expect the ryot to use a different tine or point for different kinds of work ; and we must provide him with the most useful general purpose one available. This is, I think, the double-ended, or reversible, cultivator shovel so commonly used on American machines. The right size is probably $2\frac{1}{2}'' \times 9'' \times \frac{1}{4}''$, and it should be thoroughly convex laterally and with a good longitudinal curve. They ought not to cost more than annas 4 each if imported in large quantities and quite a good sample can be made locally of angle iron at about that figure, and the latter course would probably be necessary at first if the boltless stirrup backed type is to be used.

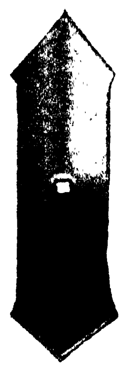

Fig. 7.

We are now in a position to build up our complete frame. The essential length of the horizontal section is determined by the space necessary for the tine positions and the skid, and the details of the horizontal section depend on whether the tines and shanks are to be bolted or wedged into position, as will be seen in Figures 12 and 14.

(1) The simplest vertical section is as below, where the central horizontal frame member, the pole and the handle form a complete triangle. It will at once be seen that by keeping the frame flat we add an extra 15″ or 16″ to its horizontal length. This makes it ugly and unwieldy and difficult to control.

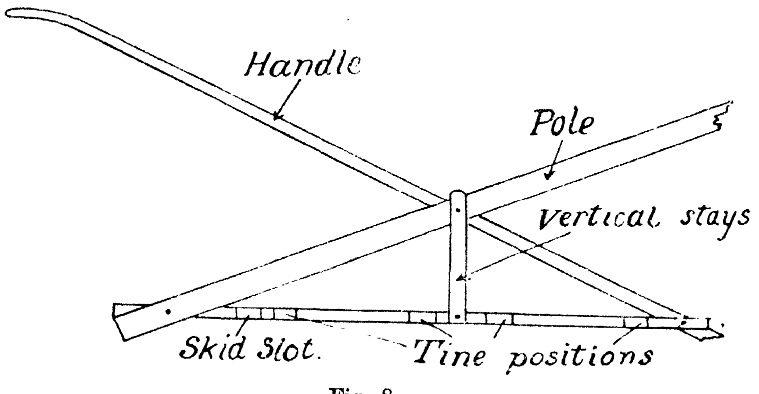

Fig. 8.

(2) By turning up the two ends at the cost of 2 bends of about 70 degrees each, we reduce the basal length by a foot from 4′ to 3′.

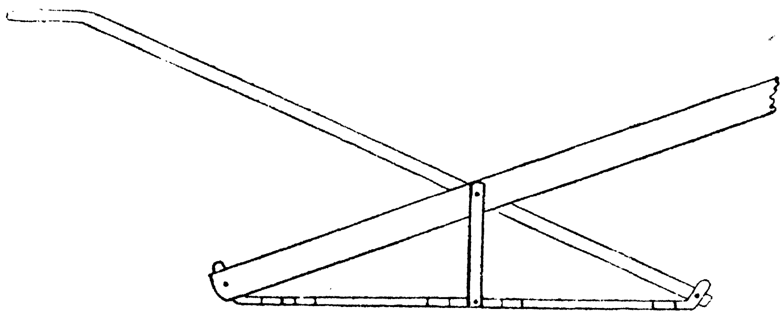

Fig. 9.

In both these types only one handle can be fitted and that is weak because its point of support, which will be rather forward of the centre of the frame, is a long distance from the grip.

(3) By bending the front end of the central horizontal member vertically into the air to meet and join the pole, we make a separate complete triangle of pole and frame, further strengthened by the handle crossing the triangle as shown in Figure 10. This in turn is further strengthened by moving the vertical stays from the middle of the frame to the rear end of the side members as shown.

In this form either single or double handles can be used, the only alteration being a reversal of the stays to slope out from the frame instead of into the central handle.

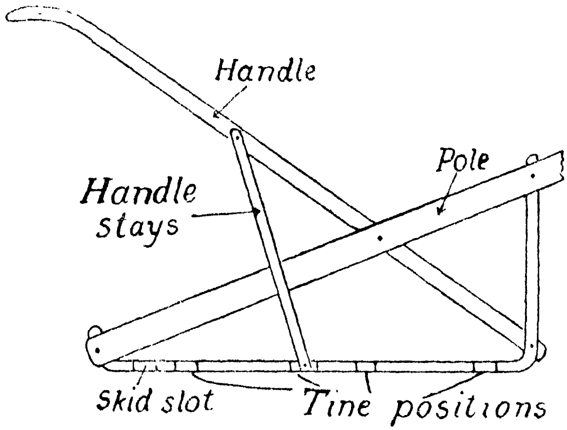

Fig. 10.

(4) In this form (Figure 11) the pole and frame form one triangle and the handles and stays are fitted separately. The handles are more easily made and fitted but the control is not so rigid as in 3. We have made and tested by hard use all four types of frame and undoubtedly No. 3 is the best for general use and is sufficiently easy to make as to be very little, if any, more expensive than 1 or 2. Further it is so well braced that probably lighter metal can safely be used than would be wise in any of the others.

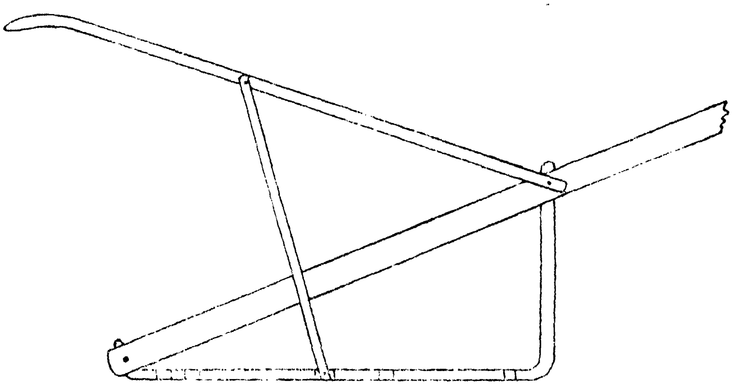

Fig. 11.

In all earlier trial models we used $1\frac{1}{4}'' \times \frac{3}{8}''$ mild steel bars, but recently have been trying with $1'' \times \frac{1}{4}''$ only ; as far as can be judged at present, this is sufficient certainly in frame No. 3 above. But engineers will, I suppose, object to bolting $1\frac{1}{4}'' \times \frac{3}{8}''$ tine shanks to $1'' \times \frac{1}{4}''$ frames. At the same time a frame of $1\frac{1}{4}'' \times \frac{3}{8}''$ is stronger and heavier than would be required for 3 tined work, *i.e.*, with small bullocks, only.

In our boltless model I would propose using bolts to fasten the pole and handle as they would require shifting very rarely. Only the tines require moving at all often. In this model therefore we can safely use $1'' \times \frac{1}{4}''$ metal for the frame, as the pole and handle provide large bearing surfaces, and the slotting doubles the frame at other critical points. This model therefore can be simply settled as per figures Nos. 12 and 13.

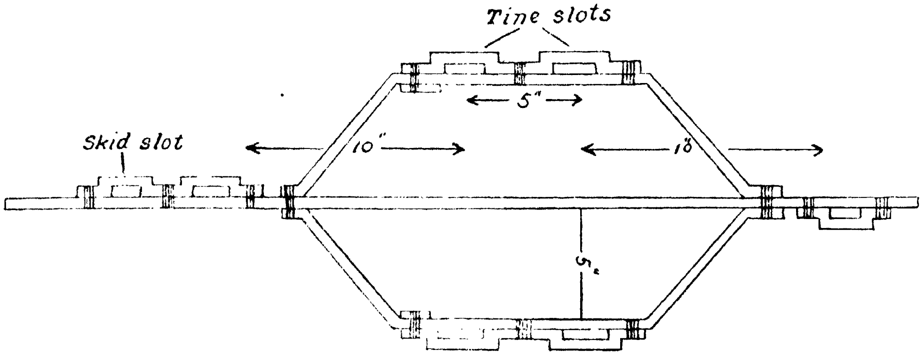

Fig. 12. Bihar 3-tined cultivator. Scale, $1'' = 7\frac{1}{2}''$

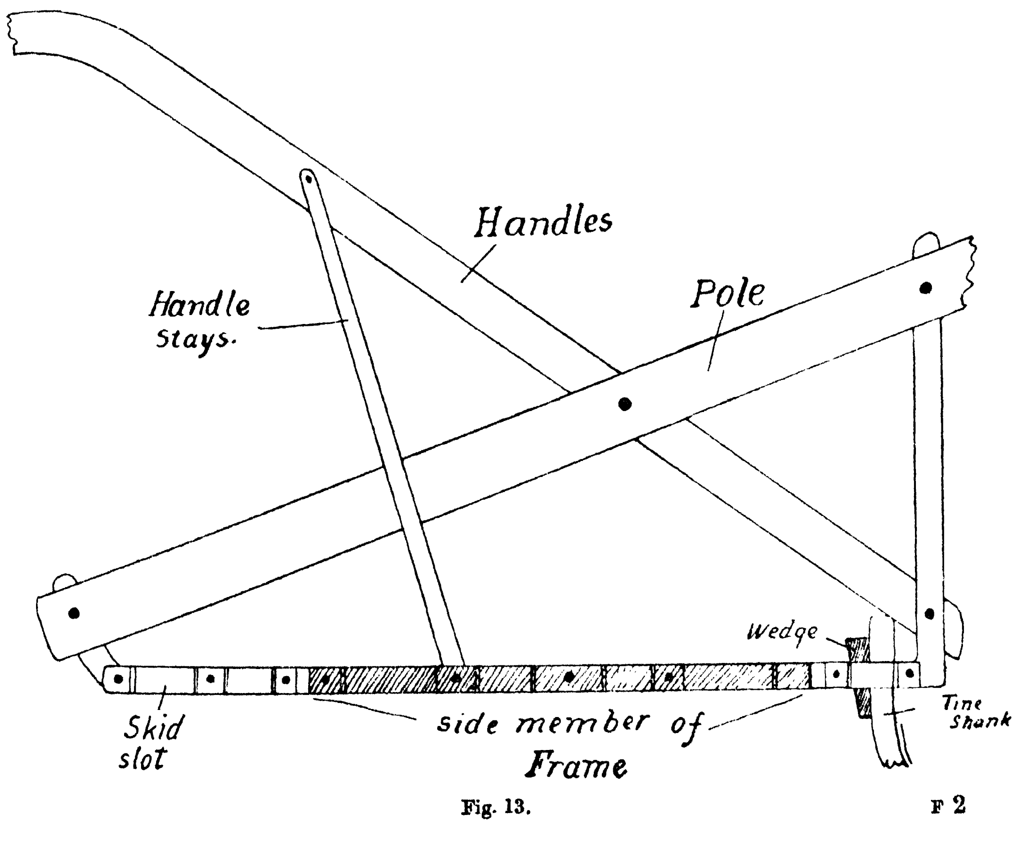

Fig. 13.

The use of bolts presupposes a higher level of general intelligence which probably goes with rather larger bullocks and better cultivation generally, *i.e.*, wider spacing and larger fields. It might therefore be wise in this model to compromise thoroughly by incorporating with the $1\frac{1}{4}'' \times \frac{3}{8}''$ frame members a slight modification of shape which will enable us to add extra pieces at will, and, at little extra cost, convert our three-tined cultivator into a 4 or 5 tined one. By keeping the front end of the frame pointed as before, but by making the back square, and at the same time altering slightly the side tine positions, we can easily add the extra side pieces and convert our frame from a 3 tined one to a 4 or 5 tined one. At the same time I would advocate fitting iron handles, single in front of the pole handle crossing, and double behind, as so fitted, the implement is increased greatly in efficiency and ease of working and very little, if any, in cost. Such a frame and handles properly made and put together should last a life time; and, of the complete implement, all that should need periodical renewal, are the pole and the tines. This quality of long life will undoubtedly appeal to the ryot; particularly as so many will inherit the debt incurred on the first purchase of the implement. Let them at least inherit also the main part of the cultivator.

It may, quite reasonably, be objected that though insisting all along on the need for cheapness and simplicity I am advocating designs unnecessarily large and complex. No cultivator will purchase such an implement if it will do for one kind of work only, and if he would have to keep others to do other jobs; but for one of such general utility as this, the demand is unlimited. From considerable experience and a very large amount of detail testing, I conclude that 10″ is the

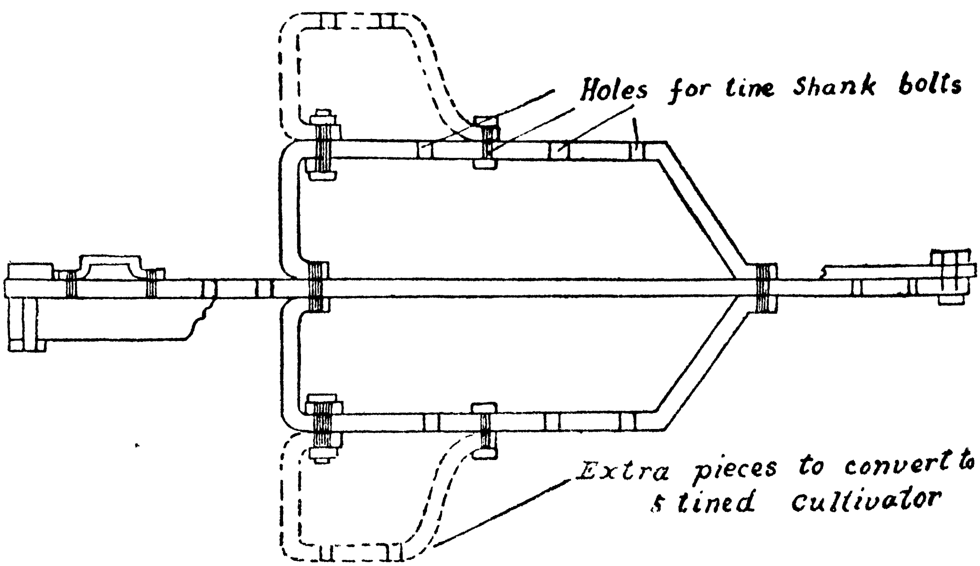

Fig. 14. The Bihar 3—5-tined cultivator. Scale, $1'' = 7\frac{1}{2}''$.

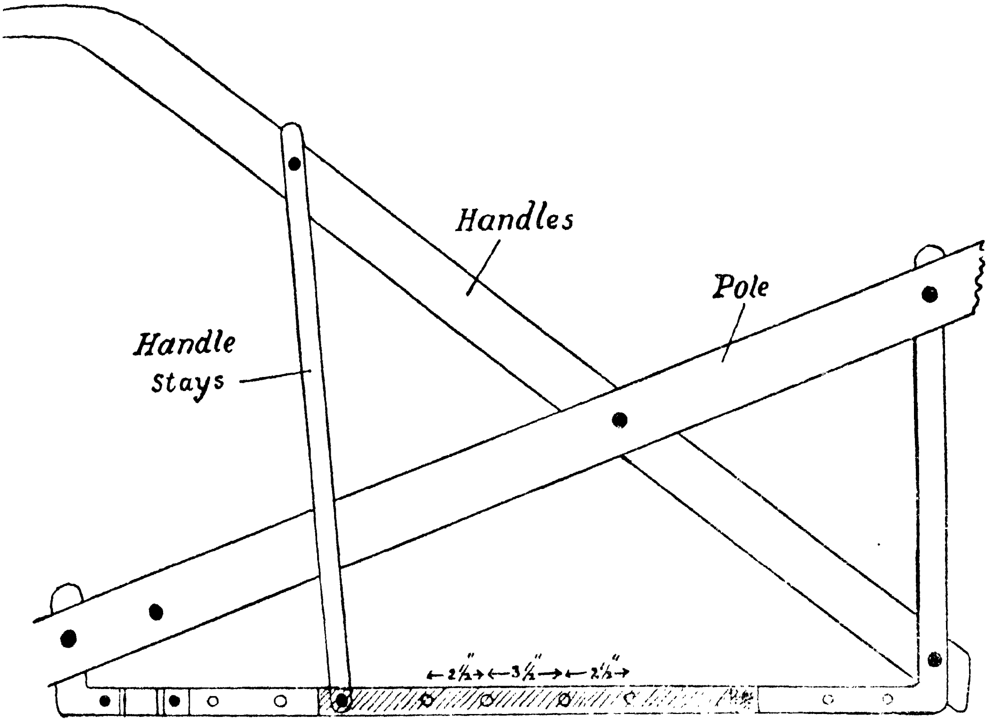

Fig. 15.

absolute minimum distance at which one tine may follow another in broken moderately clear land ; while the additional allowance of 5", and the space thus provided for irregular setting of side tines, reduces blocking and improves the work far more than proportionately to the extra cost. Again the size can be reduced slightly by utilizing the rear portions of the side members for tine settings ; but to do so means that when the centre tine is moved from front to rear or *vice versa*, both side tines have also to be moved to get the proper spacing. In the comparatively symmetrical model advocated, the moving of the centre tine only, reverses the triangle, but keeps the spacings. The implement is used intelligently entirely in proportion to the ease with which the adjustments can be made. Altogether, the types suggested are the result of a very thorough exploration of the possibilities from both points of view : the range of trial models we have made and worked, form a useful imitation of Ford's museum of the early types of his car ; and the types now advocated will do the work required and can, as far as I can judge from the cost of material

and labour involved in making up in the farm smithy, be produced and sold at less than Rs. 10 each. In fact either type of the " Bihar Cultivator " advocated seems cheap enough to be within the means of most ryots, is so adapted to bullock draft in small plots that it will work anywhere the country plough will, is light and easily transported, and at work is so handy that it can be flicked over *bandhs* and *ails* and irrigation channels with one hand without even slowing the bullocks, while it will effectively intercultivate crops; in short, a modern agricultural implement rigidly adapted to the most ancient conditions of work.

(To be continued.)

FENCING WITH STONE WALLS AS A REMEDY AGAINST DAMAGE BY WILD PIGS.

BY

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In many parts of the Bombay Presidency damage by wild pigs is a constant menace to agricultural interests. In the report of a recent Government Committee, it was estimated that the *direct* damage by wild animals in Bombay amounts to seventy lakhs of rupees annually and the greater part of this damage is caused by wild pigs. The most affected regions are, of course, those on the borders of large forest areas, which form practically indefinite reservoirs of pigs and among these the country adjoining the forests of North Kanara, whether in the Kanara or the Dharwar District, is perhaps the worst affected. The present article is an attempt to describe how in this area the use of fencing by stone walls has begun to develop, and promises to afford a means of really dealing with the plague.

The area affected, known as the Mallad, has suffered very badly for the last thirty years, and, so far as can be ascertained, the increasing care in the preservation of the forest has led to an increase in the pest and in the damage done by it. The country, in fact, has been declining in prosperity and in population. For this decline, no doubt, plague and influenza have been in part responsible, but a considerable part is, by common consent, due to wild pigs. As a result of this prevalence, continual watching of the crops—chiefly rice—by night during much of its period of growth is necessary. This, with a declining population, has tended to exhaust the strength of the cultivators, and, as a result, the area is said to have become more and more malarial and unhealthy. Very large areas have, consequently, gone out of cultivation, as the people have forsaken their lands for areas where wild pigs are not such a pest.

No agricultural improvement is possible in this region without protection against wild pigs. A fence of any kind round individual small holdings is an impossibility owing to the cost, except when very valuable crops like sugarcane are grown, and in this case temporary fences are used. With the crops of rice and millets, such fences are out of the question. Taking four acres of rice and six acres of upland to be the maximum limit for cultivation with one pair of bullocks in the Mallad, the cost of enclosing this with a pig-proof fence would be at least Rs. 800, or Rs. 80 per acre, which is prohibitive. If, however, land could be enclosed in five hundred acre units, instead of in units of ten acres, the cost per square piece would only be

Rs. 5,600 or Rs. 11 per acre, which is quite within the possibility of being used. Still larger areas would be of course still cheaper. The only way of securing fencing in this manner is by the use of fences erected by communal action, either by the formation of a co-operative society, to include all the landowners of the fields enclosed, or otherwise. Propaganda on these lines was commenced in 1921.

The first communal fence attempted was at a village called Mandihal near Dharwar in that year. Labour was at that time cheap owing to famine in an adjoining tract, and as stone was abundant on the spot a wall was built of loose stones three feet high, two feet wide at the bottom and one foot wide at the top, at a cost of eight annas per yard or Rs. 880 per running mile. The organization of this communal scheme was not easy. There were disputes about the basis on which the cost of the work was to be divided among the landholders inside the area enclosed. There were absentee landlords whose indifference had to be met and overcome. There were Government waste lands which had to be partly included, and stone had to be obtained from adjoining forest areas. Fixing the line of the fence was difficult as the boundaries of many fields were crooked, while, for economy's sake, the fence line had to be as straight as possible. These difficulties were, however, all surmounted.

When we designed the wall, little information was available as to the capacity of the wild pig to jump over walls. The wall, originally made three feet high, was soon found to be too low, and in the second half of the scheme was raised to four feet. Further, the wall was found only to be efficient when flat and not round stones were employed. The first walls at Mandihal are, therefore, only a partial success. They enclose respectively 360 acres and 514 acres with one common wall between the two blocks. The value of land inside even with this imperfect protection has increased already so much as to repay the landowners for a very large part of the cost of the wall.

The idea of a communal wall was, however, soon taken up by the people in the affected tract, and the peasant cultivators of three villages began to build such walls without even waiting to see the result of the first experiment. Co-operative societies were organized in these three villages when the work was already half done. Two further villages rapidly followed suit, and three further societies were organized in 1924.

The following details with regard to some of these walls give an idea of the nature of these protective measures and their cost :—

(1) *Birwalli.* The area protected by the Birwalli wall is 1,500 acres, and its length is $2\frac{1}{4}$ miles. In this case the area is not actually enclosed but simply runs along the forest boundary adjoining the village. The wall was made $4\frac{1}{2}$ feet high, 3 feet wide at the bottom, and $1\frac{1}{2}$ feet wide at the top and actually cost Rs. 4,800. Repairs have been a difficulty in this case, but the people are well satisfied with the general result.

(2) *Bendalgatti.* In this case the area completely enclosed by the communal wall is 916 acres, and its length is $3\frac{1}{2}$ miles. The dimensions were the same as in the last case, and the cost was Rs. 5,167. The question of repairs has also been a difficulty in this case.

(3) *Astgatti.* This wall was again made on the borders of the forest only, but was a continuation of the Birwalli wall referred to above. It protects 934 acres, has cost Rs. 3,227, and is two miles long.

(4) *Nelliharvi group of villages.* This is again a wall along the borders of the jungle in continuation of that at Astgatti, and is four miles long. It protects 2,100 acres, and is excellently constructed, five feet high and substantially built. It has cost Rs. 6,800.

(5) *Dhumwad Kurankop.* This is a linear wall along the hills, 3·3 miles long, and protects 2,482 acres at a cost of Rs. 4,765. In this case the question of repairs is dealt with by settling a *waddar* (or professional worker in earth and stone) on land protected by the wall where he can also cultivate, provided he keeps the wall in repair.

These cases show how far the idea of co-operative walls for the protection of villages from pig attack has actually led to their construction. Two other groups of villages are now collecting the capital required, and the work will probably be undertaken in the present season. Some, it will be seen, are enclosures ; more are, however, walls along the boundary of the forest area, continued from village to village.

A recent investigation has been made as to the benefit derived from the construction of these walls. In these cases the *annual* advantages derived under three different heads are as follows :—

Annual advantages.

——	Birwalli	Bendalgatti	Astgatti
	Rs.	Rs.	Rs.
1. Produce of waste land now cultivated	1,250	875	400
2. Saving on cost of watching crops	1,194	704	601
3. Reduction of actual damage	834	1,008	818
TOTAL .	3,278	2,587	1,819

All these benefits are annual ; the first and third are actual increases of net profit as a result of the wall. The second represents a saving in energy, in health, and, in some cases, in out-of-pocket cost. It is estimated that with walls constructed with our latest experience and kept in thorough repair, the total annual advantage

recorded above would be increased materially to Rs. 5,140 at Birwalli, to Rs. 4,722 at Bendalgatti, and to Rs. 3,064 at Astgatti. As a result, numerous schemes are now being proposed.

When schemes of this sort are being prepared, however, a number of difficulties arise, the chief of which are (1) the equitable distribution of cost among the different members, and among different villages when a group of villages is included in one scheme, (2) the indifference of absentee landlords, and, often, the difficulty of approaching them, (3) the inability of the poorer cultivators to pay their share of the capital cost, and (4) the opposition of a small proportion of the landowners protected, and their refusal to pay their share of the cost.

It usually requires great patience to get over these difficulties, and it is only under the stress of a great and constant menace that the people will unite to build the protection required. As a result the question has been raised again and again whether it would not be feasible and wise to compel a small number of recalcitrant landholders to come into a communal scheme for the protection of village lands from wild animals. A bill to provide for this, so that support from the owners of seventy-five per cent. of the land will ensure that the scheme will be carried out, is now under consideration in Bombay.

The walls so far built, except the first one at Mandihal, have been put up by co-operative fencing societies specially formed for the purpose. As the organization of societies for such purposes is somewhat novel, it may be worth while describing the bye-laws under which they work. The model bye-laws, issued by the Registrar of Co-operative Societies, Bombay, state the object of such a society to be "to erect and keep in repair fences, walls, etc., in the cultivable lands" of a village "for the protection of crops against wild pigs or other animals and to obtain loans for the purpose within the co-operative movement and to secure the regular repayment of the said loans." The existence of such societies is *limited to ten years.* but it may be continued beyond this by a resolution of the general meeting, with the approval of the Registrar and of any bank or society to which it is indebted.

The actual procedure which is adopted in the carrying out of the objects of these societies is described as follows in the model bye-laws :—

"Within three months of registration the managing committee shall draw up and a general meeting shall approve a schedule stating in annas or fractions of annas to the rupee in what proportion each member, whether owner or cultivating tenant, shall contribute to the share capital of the society and to the repayments of the loan or loans. A copy of this schedule shall be submitted to the Registrar for registration as portion of the bye-laws. If in any case only the owner or the cultivating tenant or tenant of a field is assessed to contributions in this schedule, then the agreement of the other party, whether tenant or owner, to this assessment of contributions and his waiver of other claims shall be obtained and attached.

"And as soon as possible after the completion of the schedule, an estimate of the cost of the fencing shall be made and 20 per cent. shall be added to such estimate.

At least one-ninth of the total so arrived at shall, thereupon, be collected from members according to the *annewari* of the schedule prepared, and be credited in their names as being their paid up share capital and the funds so raised shall be deposited in the Central Bank to which the society is affiliated.

"The society shall, thereupon, apply to the Central Bank for a loan not exceeding eight times the amount so collected and deposited and ask that the amount shall be deposited in the society's name in its current account at the Bank.

"On the loan being sanctioned and credited, the society will proceed to order the materials required for fencing and shall proceed to erect the fencing according to estimate. Any balances remaining after the execution of the project shall remain in deposit in the Bank and shall serve as a repair fund and to meet contingent and establishment expenses.

"If the funds so raised prove to be insufficient for the execution of the project or for the purposes of a repair fund, then any additional amount required shall be raised by a levy, in the proportion fixed in the schedule, from all members and by the raising of additional loans, if obtainable.

"As security for all loans each owner member shall execute mortgage bonds which shall be endorsed by the society and transferred to the Central Bank which grants the loans."

So far as repayment of the loans taken for the construction of the fence or wall is concerned it is provided that "each member shall be bound to repay his share, settled according to the schedule, in each instalment of the loan obtained by the society with interest at $9\frac{3}{8}$ per cent." But the liability of each member is unlimited.

The justification of such societies is their success, and they promise to be very successful. The building of communal walls or fences well designed by the aid of expert officers of the Agricultural Department promise to furnish by far the best means of village protection from wild animals. Pig-proof wire-fences have not been used on large areas for communal protection in the Bombay Presidency hitherto, though it is clear that they are as effective as walls, and, where suitable stone is not abundant, are the natural means of protection. In the present article, however, an attempt has only been made to describe what has been actually done on a large communal scale, and the methods of organization which promise to be of wide or even of general application.

A METHOD OF GROWING NORMAL PLANTS OF COTTON FOR OBSERVATION AND THE BEHAVIOUR OF BROACH COTTON UNDER THESE CONDITIONS AT SURAT.*

BY

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To grow cotton uninfluenced by external factors has ever remained a problem before workers on cotton and a correct conception of the type of growth and behaviour of cotton under normal conditions is of very great importance, not only to an entomologist, but also to the plant-breeder. This was recognized by the writer from the very beginning of the boll-worm investigations. Various types of cages, big and small, were tried to keep away the boll-worm. It was easy to prevent the boll-worm on plants grown under permanent cages but the plants showed such abnormal appearances that observations made on such plants were of little use. The internodes were extremely long, the leaves thin and broad, the stems trailing and weak and ultimately we had to discard such plants. At Surat the plants under the permanent cages reached a height of 8 feet and over and continued to produce buds and flowers even in June of the following year. This year we were able to get what might be considered normal plants free from boll-worm. Detailed life-history work of the boll-worms has shown the moth to be capable of laying eggs only at night and under no circumstances was it possible to get the moths to lay eggs by day time. Therefore it was thought that it would be necessary to protect the plants at night time only. A certain number of plants were caged in the following manner and were fully exposed to the sun and wind by day time. Light wooden cages with mosquito netting were utilized to cover the plants at night. These cages were put on plants intended to be protected late in the evening at about 5 P.M. and removed again early at daybreak. The plants grew in the most satisfactory manner, free from boll-worm attack throughout the season. In order to protect the plants from caterpillars crossing over to them from other plants in the vicinity, small tin trenches were slipped over the plants when they were quite young and the trenches were kept filled with water covered with a thin film of non-volatile oil. The oil would catch any larvæ that might attempt to cross over. A precaution that it is absolutely necessary to take is that when the plants are caged in the evening they should be shaken slightly to drive away boll-worm moths that might have

* This investigation was carried out under the auspices of the Indian Central Cotton Committee.

flown to the plants by day. The plants protected thus had none of those abnormalities mentioned in the case of the plants grown under permanent big cages.

We attempt to give below some of the important differences in behaviour between these plants and others that we are accustomed to see growing under boll-worm conditions. Our observations are restricted to the growth of one season only and the publication of data with regard to these plants might be considered premature. But the writer hopes to draw the attention of other workers in cotton, especially to this method of growing plants, and publication of their experiences may help to modify this method where necessary.

The botanical description of the cotton plant known as Broach Deshi indicates it to be of a rounded bushy shape with a comparatively large number of vegetative branches arising from the lower portion of the plant. This description is correct but there is no allowance made for the purely external factors, which vary from season to season and yet seem to have a profound bearing on the growth of the plant and the final shape it attains.

Important among these factors is the alteration in the growth brought about by the attack of insects even when the plant is quite young. The spotted boll-worm is the most important of these and is found to attack the growing shoots of cotton very early in the season and effectively to cut short all further growth in height. The number of plants that get attacked thus vary from season to season and the damage may extend from 50 to 80 per cent. according to the severity of attack. The average height of a large number of plants in a field was only 36 centimetres, whereas the plants under non-boll-worm conditions in the same field grew to a height of 90 centimetres. In addition, this attack on the shoots has a considerable amount of influence on the number and kind of branches borne on the plants. The following statement will make it clear.

Kind of plants	Average No. of primary fruiting branches	Average No. of nodes on the main stem	Average height in centimetres
Under boll-worm conditions	4·9	18	36
Under non-boll-worm conditions	26·0	40	90

Each one of the nodes on the primary axis is capable of giving rise to a branch and our field observations show that any check to growth in height given by the boll-worm is manifested, not only in the less number of fruiting branches, but also in the longer and better development of vegetative branches. It is this diversion of growth which gives the Broach cotton its bushy nature combined with the dwarfness brought about by the shoot attack. The photograph of a plant allowed to

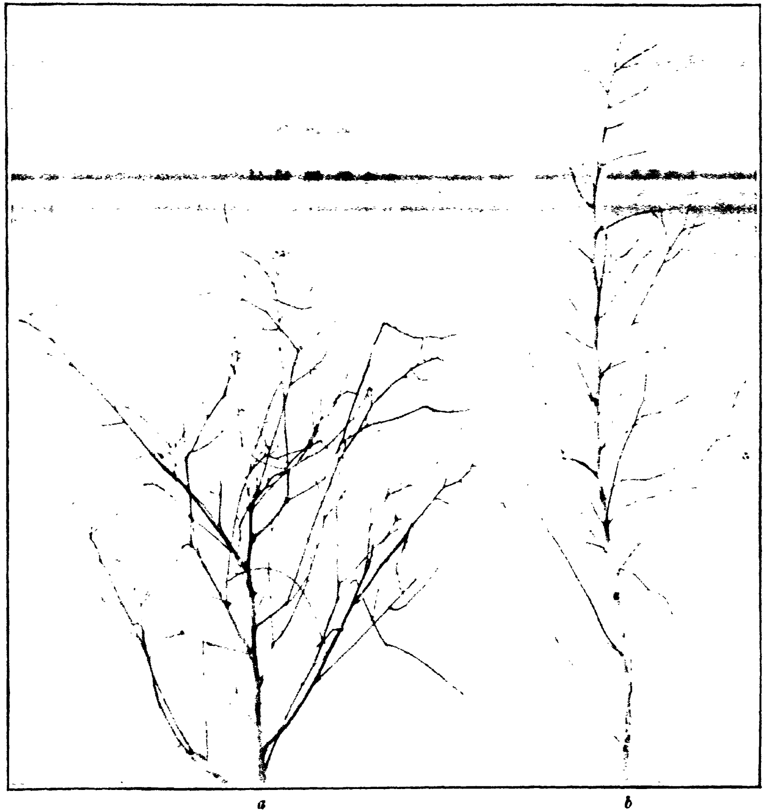
grow normally without interference from the boll-worm shows a tall conical growth common to many other cottons. The existence of a large number of vegetative branches on Broach Deshi when compared to either the *neglectum* or the *indicum* cottons is not in any way denied. But the alteration brought about in their number as also in their vigour of growth is at the same time unquestionable, and this is the result of a purely external factor, the boll-worm. The photographs, one of a normal plant and one growing under boll-worm conditions, will make this point clear (Plate XL).

Kind of plants	Average bearing on primary fruiting branches	Average bearing on vegetative branches	Average bearing on axillaries of sympodia	Total bearing
Under boll-worm conditions	4·9	12·8	10·2	28·0
Under non-boll worm conditions . .	20·8	4·1	6·5	31·4

In an unprotected plant most of the bearing is to be found on the vegetative branches and axillaries of the primary fruiting branches, particularly the latter, which put on an unusually fine growth when the tops of the plants are pruned by the boll-worms. On the protected plants the bearing is concentrated on the primary fruiting branches and it is least on the vegetative ones. Most observers have pointed out the necessity of the existence of a large number of fruiting branches to let the plants flower early. Indication of this truth is exemplified in the same strain as the present one (1027 A. L. F.) where protection from boll-worm alone is enough to allow the plant to bear all its normal fruiting branches which under ordinary field conditions get destroyed by the boll-worm. The plants therefore do necessarily flower earlier than plants attacked by the boll-worm. The great incentive given to the growth of the vegetative branches and axillaries from pruning by the boll-worm makes the plant flower as late as November and December, while, as we shall see later, the plants under non-boll-worm conditions have very nearly finished their flowering when the field plants are beginning to bear.

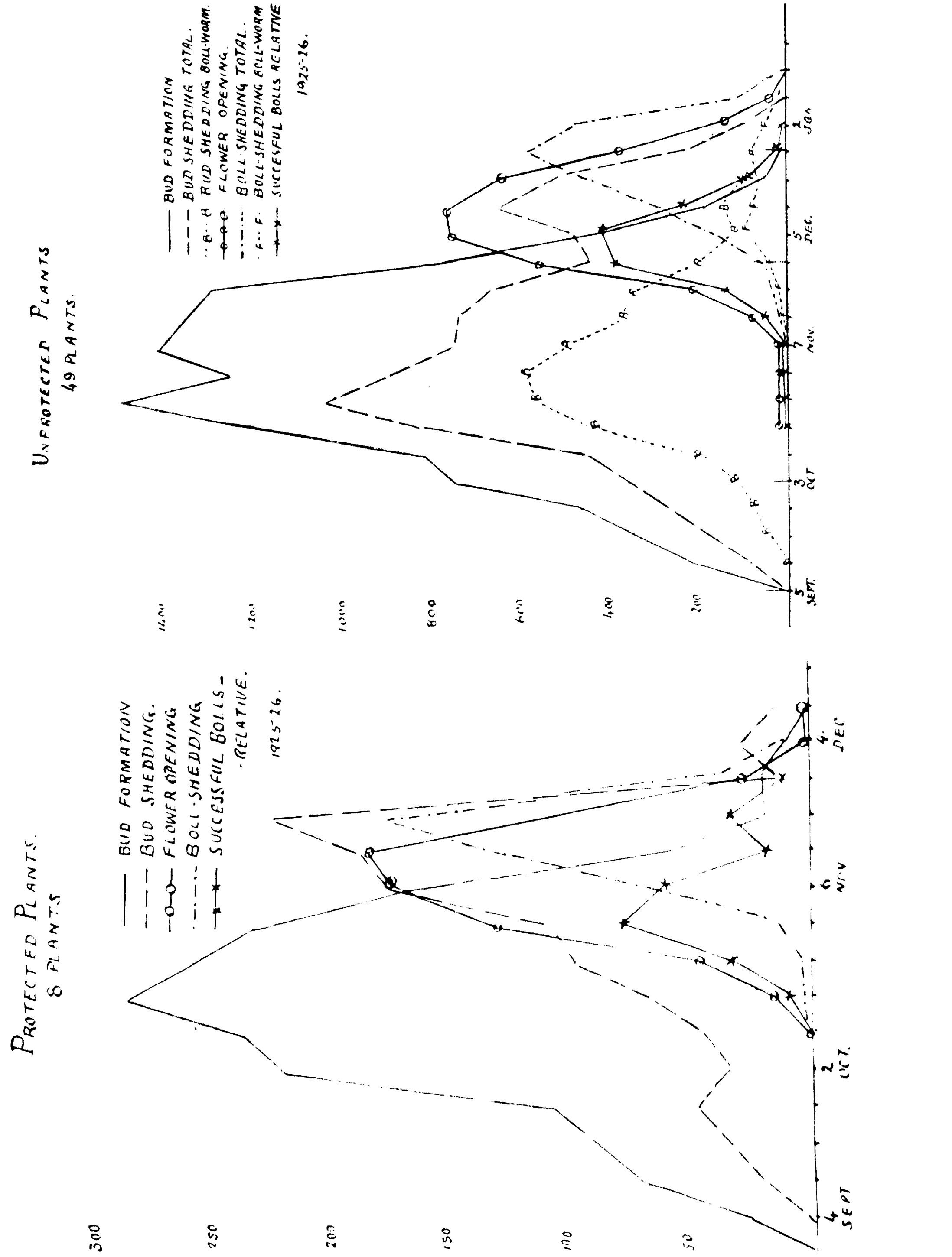
Our observations on the growth of cottons at Surat show three distinct stages, fairly sharply marked off from each other. These are : I—vegetative phase when the energies of the plant are concentrated on the production of branch and leaf, II—reproductive stage when the plants develop buds and flower, III—ripening stage when the bolls grow and finally split open. With the opening of bolls the plants may be said to have finished their life. These three stages are not rigidly separated by any definite interval of time but merge into each other slightly. The production of buds and flowers is however the most important period in growth, on which will

Plant protected from boll-worms. (Note the tin trench round the plant.)



(a) Boll-worm condition. (b) Protected from boll-worms.

PLATE XLI.



UNPROTECTED PLANTS
49 PLANTS
BUD FORMATION
BUD SHEDDING TOTAL.
BUD SHEDDING BOLL-WORM.
FLOWER OPENING.
BOLL-SHEDDING TOTAL.
BOLL-SHEDDING BOLL-WORM
SUCCESSFUL BOLLS RELATIVE
1925-26.
1400
1200
1000
800
600
400
200
5 SEPT.
3 OCT
7 NOV.
5 DEC.
2 JAN
PROTECTED PLANTS.
8 PLANTS
BUD FORMATION
BUD SHEDDING.
FLOWER OPENING
BOLL-SHEDDING
SUCCESSFUL BOLLS -RELATIVE.
1925-26.
300
250
200
150
100
50
4 SEPT
2 OCT.
6 NOV
4 DEC

ultimately depend the yield in *kapas*. A clear conception, therefore, of what occurs in a normal plant will be very instructive and help us to understand the changes brought about on plants in field conditions.

The graphs in Plate XLI show curves representing the flower-bud and flower production in both these types of plants. On normal plants free from boll-worm, the bud production commences in the beginning of September but the maximum bud-production is to be found concentrated in October. The flower production commences 4 to 5 weeks later and is finished by the end of November. This flower-bud development and flowering period is fairly marked off and is distinct from the earlier vegetative phase and the later ripening stage of cotton. The alteration brought about in the bud and flower production by external agencies, in this instance the boll-worm, is clearly seen when we compare the performance in unprotected plants. The same three stages are doubtless manifested in field cotton as in the protected plants. The buds begin to appear about the same time but this stage continues on the unprotected plants 3 to 4 weeks later than on the protected plants. This lengthening of bud production is, we believe, due to the continuous pruning the plants are getting on account of the boll-worm attack on the top shoots as well as on the side shoots. It leads necessarily to a renewal of vegetative growth and consequent delay in the development of reproductive forms. This behaviour is common to many other plants besides cotton. The probable effect of this continuous pruning can be conceived when the boll-worm is known to spare neither the buds, flowers nor bolls.

The effect of this lengthening of the vegetative growth is manifested more markedly when the flower formations in the two sets of plants are compared with one another. The maximum flower production in the protected plants is distinctly a month ahead of that on the unprotected plants on which a large number of flowers are seen to appear when they have almost ceased to do so on the protected plants. This concentration of the flower production into a shorter period, as can be seen from the curves, is also a marked feature of the protected cotton plants and is bound to have its own effect besides earliness on the final opening of the bolls. We find this to be finally expressing itself in the extremely early picking of cotton from the protected plants which occurs a month or a month and-a-half earlier than on unprotected plants.

SELECTED ARTICLES

RECENT PROGRESS IN COTTON-GROWING IN INDIA.*

BY

B. C. BURT, M.B.E., B.Sc.,

Secretary, Indian Central Cotton Committee.

It is only natural that the recent enhancement in the supply of American cotton should lead to less interest being shown, for the time being, in Empire cottons capable of replacing American. Nevertheless, since it is by no means likely that the enhanced American supply will be maintained, or that all anxiety about the world's cotton supply is over, it is as well to take stock of the present position as regards other supplies. Especially is this the case where India is concerned, not only because India is easily the second largest cotton producer in the world, but because certain very definite changes in Indian cotton production have taken place which appear to be of a permanent or a semi-permanent nature.

The steady increase in Indian cotton production since the war is remarkable. The estimated production figures, as given in the annual final cotton memorandum published by the Director-General of Commercial Intelligence and Statistics, for the last five years are as follows:

	In bales of 400 lb. each.
1921-22	4,485,000
1922-23	5,073,000
1923-24	5,161,000
1924-25	6,088,000
1925-26	6,038,000

At the time of writing no estimate of the 1926-27 crop is possible, for cotton-sowing extends from May to November in different parts in India.

* Reprinted from *The Empire Cotton Growing Review*, IV, No. 2.

The figures for the exports *plus* local mill consumption give the following totals for the commercial crop for the last five years :

	In bales of 400 lb. each.
1921-22	5,329,000
1922-23	5,582,000
1923-24	5,286,000
1924-25	6,173,000
1925-26	5,758,000

The latter, however, requires correction to allow for variation of internal stocks. For up-country stocks no figures are obtainable, but actual census figures for stocks in Bombay published by the East India Cotton Association on August 31 are available, and are as follows :

August 31—	Bales
1921	1,212,000
1922	988,000
1923	692,000
1924	512,000
1925	373,000
1926	427,000

It is probable, due regard being given to the way in which cotton is financed and sold, that up-country stocks except those held by mills do not vary greatly except in very abnormal years. Mill stocks are not completely reported, but on the basis of those collected by the Bombay Millowners Association mill stocks* *outside Bombay Island* on the above dates may be taken as follows :

July 31—	Bales
1921	586,000
1922	357,000
1923	331,000
1924	506,000
1925	448,000
1926	438,000

Applying this correction the *commercial* Indian cotton crop for the years under review would be :

	Bales
1921-22	4,894,000
1922-23	5,240,000
1923-24	5,281,000
1924-25	5,976,000
1925-26	5,802,000

To compare these figures with the final estimate of production issued by the Department of Commercial Intelligence and Statistics, a figure should be added for domestic

* Mill stocks in Bombay mills are included in the East India Cotton Association's annual census of Bombay cotton stocks.

consumption for other than mill purposes. Such consumption not only includes hand spinning, but, what is more important, all purposes other than spinning, such as the padding of the quilted coats, etc., so largely used in Northern India. The conventional figure adopted at present is 750,000 bales per annum, but there is grave doubt as to whether this is anywhere near the truth ; no means exist for verifying it, but for our present purposes we can ignore it. The main conclusion from the figures presented is that the Indian cotton crop, instead of fluctuating in the neighbourhood of 4 million bales, now approaches closely to 6 million bales. How far that figure will be maintained on a lower range of prices is largely a speculative question, but two factors of importance may be mentioned. The increase has come partly through the development of new cotton-growing areas, which represent a permanent addition to Indian cotton production, and secondly, there has been a steady increase in the average yield per acre which, for a variety of reasons, seems likely to be maintained.

But more important perhaps than the increase in total production is the change in the composition of the crop. In 1915-18 India produced 4,160,000 bales of cotton per annum, of which 2,999,000 was short staple cotton and the remaining 1,161,000 bales cotton of medium staple ; now the figures are : short stapled, 3,893,000 bales, and medium stapled, 2,145,000 bales. The staple of Indian cottons ranges from $\frac{1}{2}$ to $1\frac{1}{8}$ inches, with a small quantity barely touching $1\frac{3}{16}$ inches, and it is not easy to find a dividing line between short and medium staples. At one end of the scale the $\frac{1}{2}$ to $\frac{5}{8}$inch cottons, typified by Bengals and Oomras, are easily enough recognized ; at the other end of the scale the best Surats, Punjab-American, Cambodia, and other growths with a staple of a "commercial inch" and upwards are characteristic enough, but between these limits there is a considerable supply of $\frac{3}{4}$ to $\frac{7}{8}$ inch cotton such as Dholleras which, though of short staple according to Liverpool ideas, is yet of considerable importance to spinners in India and the East. Hence any attempt at classifying the Indian crop must be in the nature of an approximation, and the table on page 449 is only put forward as a tentative effort to indicate what portion of the Indian crop merely meets the special demand for short-stapled cottons, and what portion is a definite addition to the world's supply of medium-stapled cottons.

For obvious reasons the estimate of the long staple class is a conservative one, and does not take into consideration the fact that $\frac{3}{4}$-inch cottons can be, and are, used in some countries in yarns for which in others the cheaper styles of American cotton are used, or of the certainty that in years when the American crop is short a certain amount of substitution takes place.

Nevertheless, the table shows that India now contributes 2 million bales of cotton of staple suitable for replacing American for many purposes, and instead of having only a nominal margin of such cottons for export, now has an appreciable exportable surplus, after providing for the needs of her own mills.

Not all Indian staple cottons are suitable for export to Great Britain, for several

Progress of the Indian Cotton Crop, 1915 to 1926, by varieties and length of staple.

Varieties	Average during 1915-18 in '000 bales	Estimated crop during 1924-25 in '000 bales	Estimated crop during 1925-26 in '000 bales	1925-26 per cent increase over 1915-18
Short Staple—				
Oomras (excluding Hyderabad Gaorani)	1,631	1,970	1,926	—
Dholleras	472	606	626	—
Broach (part)	93	97	110	—
Bengals	687*	1,042	1,050	—
Comillahs, Burmahs, etc.	79	112	124	—
Coconadas	37	54	57	—
TOTAL SHORT STAPLE (BELOW ⅞ IN.)	2,999	3,881	3,893	29·8
Long Staple—				
Oomras Hyderabad Gaorani (Bani)	168	450	550	—
Broach (part)—Surat-Navsari mostly 1027 A.L.F. (staple 1 inch)†.	—	122	127	—
Broach (others)	190	114	87	—
Kumpta-Dharwar—Gadag No. 1 (staple 1 inch)†.	—	15	21	—
Kumpta-Dharwar—Dharwar No. 1 (staple ⅞ inch)†.	—	20	30	—
Kumpta-Dharwar—other Kumpta and Dharwar-American.	282	308	263	—
Westerns and Northerns—Nandyal 14 (staple $\frac{15}{16}$ to 1 inch)‡.	—	3	3	—
Westerns and Northerns—Hagari 25 (staple ⅞ inch)§.	—	6	25	—
Westerns and Northerns (others)	193	345	345	—
Tinnevellys, including Karunganni—Karunganni (staple ⅞ inch).	40	60	60	—
Tinnevellys, including Karunganni—other Tinnevellys.	66	97	106	—
Salems and Cambodia—Irrigated Cambodia (staple 1 to 1⅛ inch).	101‖	139	113	—
Salems and Cambodia—other Cambodia and Salems.	78‖	69	85	—
Punjab and Sind Americans (staple $\frac{15}{16}$ to 1⅛ inch).	43	359	330¶	—
TOTAL LONG STAPLE	1,161	2,107	2,145	84·8
GRAND TOTAL	4,160	5,988	6,038	45·1

* Average for five years ending 1914-15.
† Staple greatly improved as a result of the Cotton Transport Act, and now far more uniform.
‡ Previously also known as "Sircar 14."
§ Previously also known as "Sircar 25."
‖ Average for 1916-18. Revised figures reported by D. A., Madras.
¶ The figure adopted is that given in the supplementary cotton forecast, April 1926. The returns from cotton-pressing factories, however, indicate that the crop is considerably above the estimate, and probably exceeds 400,000 bales.

reasons. In the first place, certain cottons, of which Kumpta and Hyderabad Gaorani may be quoted as examples, have a high refraction due to the presence of considerable quantities of leaf, which renders them unsuitable for use in mills laid out for American cotton. Others, again, cannot freely be substituted for American on account of a difference in colour. Indian and other Eastern mills are laid out with large " blow rooms " capable of handling leafy cottons to advantage, and it seems likely that cottons of the type referred to above will continue to be used mainly in such mills, and that export will be limited chiefly to those types more nearly resembling American in general characteristics.

A similar reason explains the recent substantial importation into India of low-grade American cotton.* Such importations have taken place spasmodically for the past thirty years, averaging over that period some 25,000 bales per annum, imports in individual years ranging from nil to 100,000 bales, but commonly lying at about 5,000 to 10,000 bales. There is nothing paradoxical in a great cotton exporting country, whose mills consume 2 million bales per annum, importing small amounts of this nature for special purposes, and a parallel is to be found in the U. S. A. imports of Egyptian and Indian cottons. But it would seem that such imports have largely been induced by the fact that low-grade American cotton has been cheaper than certain of the better-class Indian cottons, which it can replace in those mills which have the necessary cleaning machinery.

THE NEWER INDIAN COTTONS.

It is of interest to note in what ways this expansion of the Indian stapled cotton crop has taken place. Three processes have been at work. Firstly, an increase in the area under cotton has occurred in the older staple cotton tracts. Thus the area under the various cottons included under the general term " Broach " has increased from 1,036,000 acres in 1915 to 1,387,000 acres in 1925. The total area of cotton in the Madras Presidency, practically all of which comes under the definition of medium-stapled cotton, has increased from 2,188,000 acres to 2,791,000 acres in the same period.

Secondly, the application of the Cotton Transport Act and other measures, including the organization of seed supply on a large scale, has led to the exclusion of inferior cottons from existing good staple tracts. Here the improvement has been in quality, purity, and regularity, and is less easy to express in figures, but is none the less important.

Thirdly, we have the systematic introduction of improved varieties, a process which has been going on for several years. Here, again, two methods have been employed. In the older long-staple cotton tracts properly controlled selection work followed by a thorough organization of the supply of seed has led to very considerable development. In Madras the old mixed Tinnevelly crop, a mixture of Karun-

* About 44,000 bales from December 1925 to October 1926.

ganni and Uppam types (*i.e.*, of *G. indicum*, *G. herbaceum*, and of various hybrids) has been replaced to a very great extent by the Karunganni type ; indeed, the area under Karunganni cotton is now believed to approach 300,000 acres. Further, the original " bulk " Karunganni is now being steadily replaced in turn by a later selection of still greater regularity, the Company type of Karunganni, of which the production is now placed at 40,000 bales.

In the Surat cotton tract of the Bombay Presidency, and in adjoining Indian State territory, an area of some 500,000 acres has been practically cleared of shorter-stapled intruders, whilst the pure line selection 1027 A.L.F., a cotton of $1\frac{1}{16}$ to $1\frac{1}{8}$ inches staple, is being steadily pushed throughout the tract. The production of the pure strain from controlled seed has reached 50,000 bales, but this does not represent the whole of the progress made, for it is believed that within two or three years practically the whole of this large tract will be growing one improved strain of cotton. Similar work is going on in the Kumpta Dharwar tract, and the pure line selections Gadag No. 1 (improved Dharwar Upland) and Dharwar No. 1 (improved Kumpta) now cover 97,000 acres and 120,000 acres respectively, with an estimated production of some 21,000 bales and 30,000 bales respectively. Mention should also be made of the improvement which has taken place in recent years in the Hyderabad cotton crop by the re-establishing of the old Bani (Gaorani) type on something like a million acres, and the exclusion of the short-staple Oomras type.

Next we come to the definite introduction of medium-stapled cotton in new areas, and the replacement of short-staple by long-staple cottons ; this amounts to the history of the introduction of American cotton mainly with the aid of irrigation. Since the mis-statement that the introduction of American cotton into India has been a failure has been repeated in a very recent publication on cotton-growing, it is desirable to emphasize the fact that the two most outstanding instances of the successful introduction of a medium staple cotton into general cultivation in a new tract are Cambodia and Punjab-American—both cottons of the American as distinct from the Asiatic type. The former is grown on an area of 416,000 acres producing 164,000 bales, the latter on 1,066,000 acres producing 328,000 bales.

There have been the usual legends about steady deterioration, none of which have any substantial foundation. Difficulty there has been, due to deliberate mixing with inferior cotton in the ginneries—an abuse which recent legislation should do much to stop. It is true that *unirrigated* Cambodia cotton is inferior to the irrigated crop in quality, but Cambodia cotton in Madras is essentially an irrigated cotton grown with intensive cultivation. In 1925-26 the area of irrigated Cambodia cotton was 184,000 acres, and the yield 113,000 bales. It is also a fact that some Punjab-American, mainly that grown on unsuitable land or with inadequate irrigation, has been poor in quality, and that the yields from the present strains have not been satisfactory in unfavourable seasons such as 1920 and 1921. But, broadly speaking, we have in these two varieties two important sources of

supply of extremely useful cotton. The success of American cotton in the Canal Colonies of the Punjab is an excellent augury for the development of a great staple-cotton tract in Sind on the completion of the Sukkur Barrage Canal system.

In two recent numbers of the *Empire Cotton Growing Review* have appeared the results of spinning tests, conducted with the co-operation of the Oldham Master Cotton Spinners Federation, the British Cotton Growing Association and the Empire Cotton Growing Corporation, on certain improved Indian cottons. These tests were originally proposed by the Indian Sub-Committee of the Corporation, and were carried out with the object of demonstrating under commercial conditions how far certain Indian cottons were capable of replacing American cotton under standard Lancashire conditions. The results of two years' tests may be summed up as follows:

The best Punjab-American, Madras Cambodia, Surat 1027 A.L.F., are definitely suitable for use in Lancashire mills, and the same applies to the improved Dharwar Upland (Gadag No. 1). The improved Madras Northerns and Westerns cottons, Sircar (now Nandyal) 14 and Sircar (now Hagari) 25. are also suitable for use in Lancashire, but are more likely to appeal to those mills which are already using Indian cotton. Karunganni is likely to appeal mainly to those mills which already use Tinnevelly cottons. Dharwar No. 1, the improved type of Kumpta, at present would seem to be too leafy for mills laid out for American cotton.

The prices which these new Indian cottons will command naturally will largely be governed by American prices, and will depend partly on the character of the ginning. Hence the recent marked development of saw ginning in the Punjab is of particular interest.

Comparative spinning tests at the Indian Central Cotton Committee's Technological Laboratory on 289F (the longest staple strain of Punjab-American at present cultivated on any considerable scale) have shown that the saw-ginned cotton was not only cleaner than roller-ginned cotton from the same batch of *kapas*, but was less neppy and produced a better yarn. Whether saw ginning is suitable for the general run of Indian cottons of the Asiatic type, and whether the general introduction of this method of ginning is either feasible or desirable, is too wide a question to be discussed in this article. What is perhaps of immediate interest is that an adequate supply of saw-ginned Punjab-American cotton is likely to be available in the immediate future for those spinners who prefer it.

To prevent future misunderstanding, it is perhaps desirable to refer here to a curious anomaly, which has come to the writer's notice. It seems that a type of cotton described as " Surat-American," and sold apparently as a saw-ginned cotton, is being supplied in considerable quantities by a well-known firm of exporters from India. Not only is no such cotton recognized in Bombay, but no American seed cotton is grown in Surat, and no Surat cotton is saw-ginned at present. On the other hand, Surat now produces the very useful long-staple cotton known as Surat 1027 A.L.F. by the Agricultural Department and as Surat " Farm " cotton by the

cotton trade in Bombay; Surat 1027 has a staple of $1\frac{1}{16}$ to $1\frac{1}{8}$ inches, and hence may be said to be of " American " staple. What actually has been supplied against this private " Surat American " type is a little doubtful. One sample supplied in 1924 appeared to be Punjab-American 285F. What has been supplied since appears to be a (saw-ginned) cotton of American type and of $\frac{15}{16}$ to 1 inch staple, and very probably was good Punjab 4F. It is extremely desirable that there should be no misdescriptions of this kind in future. The term " Surat " should be strictly reserved for cotton grown in the Surat cotton tract; the word " American " should never be included in the description of an Indian cotton unless the cotton is grown from the American type of seed. The Cotton Ginning and Pressing Factories Act now in force throughout British India (excluding Burma), and in a number of Indian States, requires all bales to carry on the central hoop the mark allotted to the pressing factory in which the bale is pressed. The prescribed marks for all presses in Surat District include the index letter " B " (Bombay Presidency), and similarly all Punjab press marks include the letter " P," and Sind press marks the letter " S." A complete list of press marks and the text of the Act and Rules will be found in recent numbers of the *International Cotton Bulletin,* and buyers are consequently in a position to establish the origin of the cotton delivered to them.

Mention has been made above of the plant breeding work which has resulted in the production of the new cottons referred to, but it is desirable to explain that this represents only a tithe of the work in progress, much of which is now reaching the stage where its effect on the character of the Indian cotton crop will be felt. What may perhaps be described, for want of a better term, as a geneticist's survey of the Indian cottons, is now in progress in practically every cotton-growing tract of importance. Improved types of Broach, Dholleras, Madras herbaceums, and Oomras cottons have now reached, or are reaching, the field-test and spinning-test stage, whilst in tracts where improved types are already in cultivation a further detailed study of the various races contained in the local varieties is being made.

Attempts are also being made, and with some promise of success, to reach by hybridization a degree of improvement not attainable by other means, and should the early promise of such work be fulfilled important further steps in the replacement of short-stapled by medium-stapled varieties of cotton will be possible. Nor have the limits of " pure line " selection been reached in many cases, and particularly is this true of the acclimatized American cottons.

The work which has been started on the physiological aspect of cotton-growing at various places should also throw considerable light on a number of factors affecting both yield and quality which are at present little understood. The development of the work of the Indian Central Cotton Committee's Technological Laboratory at Bombay not only provides for a precise determination of the possibilities of a new cotton, but considerably simplifies the work of the cotton breeder, and we trust will do more in this direction as time goes on.

From the agricultural point of view the prospects of further improvement in the quality of Indian cottons are bright. There is, however, the risk of a set-back from commercial and economic causes. The problem which faces the agricultural officer at present is whether the necessary margin between the prices of short-staple and medium-staple Indian cottons will be maintained now that the supply of American cotton, temporarily at any rate, is more than adequate. Since a large proportion of the world's spindles are designed for a staple of $\frac{7}{8}$ to $1\frac{1}{8}$ inches, the demand for the hardy short-stapled Indian cottons (*i.e.*, cottons of $\frac{1}{2}$ to $\frac{5}{8}$ inch staple) is probably not capable of any rapid expansion. On the other hand, such demand is comparatively constant, and there would seem to be indications that the price margin referred to above will narrow. Hence it is of importance that Indian staple cottons should not lose their footing in any market where they are now known. At the time of writing, the disparity between Indian and American prices, which for a time made business almost impossible, shows signs of disappearing. Spinners who have been favourably impressed with the possibilities of Indian cottons for permanent use might with advantage consider whether they would not be protecting themselves against the next shortage of American cotton, which would seem to be inevitable, however long deferred, by continuing to use Indian cottons.

BEHIND THE DIVINING ROD.*

BY

HUGH ROBERT MILL.

SPECIALIZATION in science, and the organization of research, undoubtedly lead to rapid advance in the elucidation of particular groups of phenomena ; but they are also responsible for systematic neglect of others. Thus there remain dark corners into which the investigators of the last century swept the trifles which they preferred to leave unconsidered.

For a hundred years after Cavendish had shown that a portion of atmospheric nitrogen, after being ' sparked' with oxygen, always remained uncombinable, chemists deliberately ignored this residuum ; yet soon after Rayleigh and Ramsay turned their attention to it, the sky-signs of London were advertizing by the glory of their colours that there was indeed something in it. When this has been possible in chemistry's diligently cultivated field, may we not hope to find much more lurking in those obscure places where none of the recognized sciences has as yet pegged out a claim ?

The use of the divining-rod in the discovery of springs has long been looked at askance by men of science, and not altogether without reason. People who profess to be dowsers, though usually honest folk, are sometimes fools deserving the application of their rods to their own backs, as Professor C. V. Boys hinted in these columns a quarter of a century ago. Occasionally they are pernicious paradoxers or, rarely, unblushing impostors ; yet it must be acknowledged that none of those who essayed to prove that there was nothing but folly, perversity, and imposture in this method of water-finding, has succeeded in explaining the unquestionable facts. Every one who has had to do with the water-supply of country houses knows that dowsers do find water. To ignore problems for fear that their solution might involve methods beyond the domain of conventional physics is no more justifiable than would be the banning of research into protons and electrons lest it should lead the investigator beyond the sphere of Daltonian chemistry.

Many years ago Sir William Barrett defied scientific prejudice and took up the study of dowsing. He devoted so much time to the divining-rod in literature and in practice that a systematic statement of his results has been awaited with interest and curiosity. Unfortunately, he died without completing the classification and discussion of the mass of data in collecting which he had written, as the preface tells us, between 6,000 and 7,000 letters. Some months before his death, he had

* Reprinted from *Nature*, No. 2991.

secured the co-operation of Mr. Theodore Besterman, with whom he discussed the whole subject, though for the actual arrangement and writing of the book* before us the junior colleague accepts full responsibility.

Although the book makes very interesting reading, its arrangement is far less satisfactory than the orderly sub-division in the table of contents might suggest. Mr. Besterman devotes 250 pages to evidence of the reality of the finding of water (and incidentally other things) by the divining-rod, and only about 50 pages, many of them straying back to the earlier theme, to an attempt to explain the mechanism and rationale of the process. The work is divided into three parts. Part I is entitled "Historical and Geological." The historical portion, after touching on the rise of dowsing in the fifteenth century, gives interesting details of the performances of three famous French dowsers for minerals and water and the tracking of criminals. It includes the strange case of the Abbé Paramelle, a water-finder who used no divining-rod and disclaimed any super-normal powers, yet the authors have decided that he was a dowser *malgré lui*. Much of the geological discussion strikes us as irrelevant and unnecessary, it being clear that none of the famous dowsers had any geological knowledge whatever and could not have located water by the lie of the sub-surface rocks.

Part II, though entitled "Experimental," consists of descriptions of the exploits of a large number of recent and contemporary water-finders similar to that given in Part I, with details vouched for by numerous well-known or highly respectable authorities. Three appendices cite other cases which might appropriately have come in Parts I and II. Even the short "Part III, Theoretical," continues to adduce fresh evidence as to successful dowsers while setting forth the explanation of the action of the divining-rod arrived at by the authors. There is an excellent index, which will prove useful to students of the subject, and an extensive bibliography, which might have been improved by providing some indication of the size of the books cited.

As to the value of the whole discussion, Mr. Besterman says in his preface:

"Whether the results justify this labour it is for the reader to decide; but should it be agreed that the ability to find hidden objects by other than normal means has been established, the question can hardly be answered otherwise than in the affirmative."

This is not happily worded, for it fails to define the critical term *normal*, and by extending the use of the divining-rod from the well-established case of water-finding to the detection of minerals, corpses, and even murderers, it makes room for the intrusion of false issues. Sir William Barrett probably went beyond the comparatively simple case of the divining-rod in water-finding because he hoped to reach in one stride an explanation which should include all kinds of cognition of objects undetectable by the "five senses." We agree that the evidence brought forward

* *The Divining Rod: An Experimental and Psychological Investigation*, by Sir William Barrett and Theodore Besterman. Pp. xxiii+366; 12 plates. (London: Methuen & Co.) Price 18s. net.

in the book proves the existence of a power in some people, of both sexes and of every age, race, and social position, of detecting underground springs of water which can neither be seen, heard, smelt, felt, or otherwise perceived by the vast majority of mankind. Further than this we are not prepared to go, nor do we think it necessary to seek more recondite explanations until all reasonable hypotheses for bringing the phenomena into line with the recognized or discoverable processes of Nature have been exhausted. The suggestion that radiation or vibration of some kind issuing from running water underground may be detected by the nervous system of the dowser in virtue of some hyperæsthesia is dismissed too curtly (p. 261) as "terminological perversity." The comprehensive explanation which Mr. Besterman tenders in the names of Sir William Barrett and himself (p. 267) to cover all cases of the dowser's detection of hidden things is :

"The several categories of phenomena surveyed above appear to us to lead inevitably to the conclusion that no physical theory can cover the facts. In our view the phenomena of dowsing are due to the following causative chain of psychological and physiological happenings : a suggestion is received by the dowser's subconsciousness by means of a sensibility as yet unknown to us and therefore admirably named by M. Richet cryptæsthesia ; ...... the knowledge thus supernormally obtained can become conscious ; ...... (1) if the person is one whose access to, and ability to become conscious of, knowledge in his subconsciousness is more continuous and complete than those of the normal person, the cryptesthetic suggestion received by his sub-consciousness can almost simultaneously become conscious ...... (2) By means of unconscious, automatic movements such as those which provide the phenomena of automatic writing ...... Intermediately between these alternatives may be placed (3) ; those reactions of the subconscious suggestion which cause the phenomena which may be comprehensively described as the *malaise* of the dowser."

Here a fallacy may lurk, for if "a sensibility as yet unknown to us" is conjectured as conveying cognition to the subconscious whence it obscurely wriggles into the conscious mind, could the unknown sensibility not be as easily conjectured to appeal direct to the conscious mind ? If cryptæsthesia is a "sixth sense," as M. Richet suggests, may it not be a sense capable of appreciating directly some physical property of the hidden object ? This appears to be Professor Richet's own view if we translate rightly his letter in *Nature* for December 18 (p. 876) on the explanation of "spiritualistic" phenomena :

"The hypothesis of unknown vibrations seems to me preferable. After all, why not suppose that reality emits vibrations ? Do we not know of innumerable powerfuf vibrations such as electric and magnetic waves which are only revealed by special detectors and would pass unperceived without the use of these detectors ?"

Thus Professor Richet seems to countenance the idea which occurred to us, before his letter appeared, in reading Sir William Barrett's book, that the *malaise* of cryptæsthesia may be akin to that experienced by some people in thundery

weather, which can reasonably be attributed to the action on the nervous system of the electric waves announced by wireless 'atmospherics' in advance of thunderstorms. Investigation must prove whether this is so, or if the recognized senses may in some people attain a state of hyperæsthesia and become capable of acting much more powerfully than under usual conditions. May not some people have a sense of smell (if it is smell) as highly developed as that of the dog which perceives in the dark outside a house the room in which his master is; or a sense of hearing or touch as fine as that of the bat, if that animal indeed navigates dark winding caverns by means of a natural power of echo-sounding?

It may be the prejudice of the student of measurable and calculable things which makes the hypothesis of cognition through the unconscious mind repugnant as an instrument of scientific research, or it may be ignorance of psychological methods which makes us incapable of being convinced by the arguments, while accepting the facts, brought forward in this book. Whether his explanation is right or wrong, Sir William Barrett deserves to be held in grateful memory for accumulating by his enthusiastic labour such a rich store of obscure facts. It is to be hoped that the book will inspire some open-minded investigator versed in physiology and adequately instructed in physics and psychology to make an exhaustive experimental study of the mechanics of the divining-rod and the concurrent physical and mental state of the dowser, with the sole object of seeing how it is done. Observers who take up the subject determined to prove that the whole thing is a piece of humbug, can of course discover nothing.

NOTES

SOME PRECAUTIONS OBSERVED IN PICKING SINGLE COTTON PLANTS FOR PURE LINE WORK.

The following note is written to call attention to a possible source of contamination, whereby outside seed may be unwittingly introduced into the produce picked from a single plant selection which is intended to be the parent of a pure line family. It was noticed one year, in Egypt, in a strain pure for khaki coloured lint, that at picking time numbers of white locks were found on certain plants. These white locks had obviously been brought in from adjacent white linted families, as they were found to be hanging from the ends of branches, etc., and not from the bolls. It is possible that these locks were brought in by small birds of the warbler type, many of which are to be seen flying from plant to plant in the cotton fields, searching for food. Similar small insectivorous birds are found in cotton fields in India.

Suspicions had previously been aroused by some observations in certain families which were segregating for full fuzzy, partially fuzzy and naked seed types. Here it was found that, with the ordinary single plant picking by plant observers, two types of seed—a fully fuzzy and a naked type for example—were frequently found in the single plant bag. The number of the off type seeds often approximated to six or seven, or some multiple of these numbers and—as six or seven is the usual number of seeds in a lock of Egyptian cotton—it was thought one or more locks may have been picked from adjacent plants by mistake.

The locks may however have been brought from adjacent plants by birds, as suggested above, or again, if plants are growing close together, there is some interlacing of branches, and when they sway in the wind, it can easily be conceived that a lock from one plant might get caught and pulled out of the boll by some projection on a neighbouring plant. Such stray locks, when a plant was being picked, would almost inevitably be included by the picker in the produce from that plant.

The sources of contamination noted above apply to self-bred seed, as well as to natural seed from a plant. Locks frequently are found hanging to the hooked tip of the reflexed carpel. One cannot be certain that such locks come from the boll to which they are hanging. It would be unwise therefore if the boll is a self-fertilized boll, to include that lock among the self-bred seed. Yet such a lock would by most plant observers be picked as " selfed ".

For picking single plants of pure lines, calico bags are used with a double compartment. One side of the bag is used for natural locks, and the other side for self-bred locks. The dividing partition projects somewhat from the mouth of the bag.

In picking a single plant three men are used. Two are used for gently bending and holding back the adjacent plants, leaving the plant to be picked well separated from the others. The third man first picks the naturally fertilized bolls, and stringent instructions are issued that only locks which are actually in place in the boll are to be picked. Each lock picked must come from the "heel" of the boll. No other locks are to be picked.

For the self-fertilized bolls, these are all labelled at the time of selfing, and the whole boll and peduncle is picked with its label, into the "selfed" compartment of the bag. These are checked later in the laboratory, and an opportunity is given of detecting and even retrieving mistakes. For example, the careless placing of locks from a naturally fertilized boll in the wrong compartment can be detected, as there may be too many locks for the bolls; whereas without this check it would not be detected. In such an example also, there would still remain the certainty that the locks still in place in a boll were actually self-fertilized; and all the labour of selfing would not be wasted. If the whole bolls were not picked there would be no check on carelessness of this kind. The mere fact of there being a check encourages the taking of greater care. [TREVOR TROUGHT.]

A REMEDY FOR A DIE-BACK DISEASE OF ORANGE PLANTS*.

IN the Irrigation Bungalow at Deolali, Ahmednagar District, Bombay Presidency, an orange plantation was started in 1911-12, and the plants began to bear fruits in 1918-19. In 1921-22, the die-back disease appeared and by 1924-25 it increased so much that it was expected that the whole plantation would die before long. In May 1925 half the plot was experimented upon by digging trenches and filling them with stones, bricks and plant-refuse to improve aeration of roots. The improvement shown by this treatment in 10 months was exceedingly good and an account of this was given in "The Agricultural Journal of India," March 1927. It was then mentioned that the plants without trenches had gone from bad to worse and bore very little.

The actual yield of fruit in the following season from each plot now confirms the statement made in the first report. Account of baskets of fruit from each plot was kindly kept by Mr. V. G. Gokhale, L.C.E. Seventy-six treated plants gave 300 baskets containing on an average 40 fruits in a basket, while 74 untreated plants gave only 11 baskets. Calculated on 100 plants we ge the following number of fruits, for the treated and untreated.

	Fruits per 100 plants
Treated	15,789
Untreated	595

The treated plants gave 30 times as much fruit as the untreated.

* For original account see *Agri. Jour. India*, XXII, 2, p. 114.

In May 1926 in the untreated plot of 74 plants also trenches were dug and the plants have now recovered immensely, thus confirming the effect on the first plot. It may also be mentioned here that the plot treated in 1925 has kept up its good condition.

A few lines of orange plants have been similarly trenched at Vadala and they are also showing distinct improvement [D. L. SAHASRABUDHE.]

THE RICE GALL MIDGE IN NORTH KANARA.

A GOOD deal of interest has been roused in recent years by the damage done to rice by the gall midge (*Pachydiplosis oryzæ*) in many parts of India. The records of attack, while including mention of the pest in Bihar, Bengal, Orissa, the Tamil and Telugu districts of Madras, South Kanara, and Burma,* do not seem to indicate that it also occurs in the Bombay rice-growing areas of the Konkan and North Kanara. The occurrence of very serious damage in this area in 1925, and a slight attack in the succeeding years, has caused careful attention to be paid to the pest, particularly in North Kanara, though it is now found to occur widely in the South Konkan as well.

The pest is known in Kanara by the name of the *Kanne* disease. In 1925, it was at once recognized by the rice growers as an old enemy, both in the Ratnagiri and in the North Kanara Districts. In Ratnagiri, the pest was remembered as doing serious damage to the rice crop in 1917, 1918, and 1919. In North Kanara, the records told of bad injury particularly in 1918, 1919 and 1922, while 1925 was perhaps the worst year on record. In this year, careful counts round Kumta gave over 25 per cent. of plants attacked. In 1926, on the other hand, very few plants were attacked round Kumta, and from other centres no record of damage was received.

The life-history of this gall midge has been carefully described by Ghosh,[1] and the present writer's observations simply confirm what he has found. The silver-coloured, long, tube-like gall grows very rapidly in the month of August, increasing in one day, in certain cases, as much as eight centimetres. The length of this structure is greater in August than in September, the average length in the former month at Kumta being 16 cm. and in the latter 11 cm. The maximum length noticed was 50 cm. in 1925 and 34 cm. in 1926.

The years when the pest has been most serious have been those with very heavy rainfall (over 6 inches in May, except in one case (1919), and, in this year, the

* This insect is also known to occur in the Central Provinces. (T. B. F.)
[1] *Proc. 4th Entl. Meeting, Pusa,* p. 115 (Calcutta 1921).

temperature in May was phenomenally low. This is illustrated by the following records at the Kumta farm.

	April		May		June	
	Rainfall inches	Mean Temp. °F.	Rainfall inches	Mean Temp. °F.	Rainfall inches	Mean Temp. °F.
1918 . .	..	..	*19·60*	..	*22·46*	..
1919 . .	..	*82·6*	*0·72*	*75·6*	*30·54*	*81·0*
1920 . .	..	85·1	0·05	85·7	33·07	82·5
1921 . .	..	85·6	..	87·6	31·50	82·1
1922 . .	..	*87·2*	*9·27*	*87·5*	*37·20*	*80·1*
1923 . .	..	86·3	0·11	85·2	24·53	83·6
1924 . .	..	85·8	2·62	86·0	56·24	80·4
1925 . .	..	*85·6*	*6·96*	*84·3*	*55·66*	*79.8*
1926 . .	..	81·3	..	85·1	35·46	80·0

The years italicized represent those of serious damage. In 1919, the May temperature was very low.

The figures of mean temperature are suggestive, though we have no evidence as to what is the connection between them and the seriousness of the pest.

The observations in 1925 show that the seriousness of the attack in North Kanara was closely correlated with the earliness or lateness of the rice grown, and, in the same variety, with the date of transplanting. Taking the local varieties of rice, the early Maskati type when sown in the seed-bed at the commencement of the monsoon gave only 0-5 to 2·0 per cent. of the plants attacked. When this same variety was transplanted late by 25 days, it gave 25·0 per cent. of attack. The local late Halga type gave an average of 25 to 30 per cent. of plants damaged. When sprouted seeds are sown, for late transplantation, the attack was always more serious.

Local varieties were, on the whole, whether early or late, very much less attacked than introduced types from other districts. All Kolamba rice strains from the Karjat Rice Research Station had between 50 and 75 per cent. of attack at Kumta. On the same farm, Mahadi was damaged up to 70 per cent., Jirasal up to 68 per cent., and Bhadas up to 65 per cent. The high or low lying situation of the plot, the amount of fresh running water in the field and its depth, and the amount of manure, did not appear to have any relationship to the seriousness of attack.

The attack on the seedlings themselves in the seed-bed was comparatively small. In 1925, about one per cent. of the seedlings from seed planted at the beginning of

the monsoon were attacked ; five per cent., however, were found damaged in seedlings raised a few (seven to fourteen) days later from sprouted seeds. The damage in the seed-bed became obvious about the first week in July.

In the fields, the damage appears most obvious in August, in plants transplanted about 20-25 days previously. From this time until harvest, the insect continues active, attacking the side shoots (tillers) that spring up from plants the main shoot of which had already been attacked. Even after harvest the small shoots that rise from the rice stubbles are attacked by the gall midge until the middle of December.

In North Kanara, there is a winter rice crop, grown from sprouted seed sown in puddled fields in November or early in December. This crop was attacked in 1925-26 to a small extent (0·5 to 1·0 per cent.), the damage appearing, however, up to the end of January.

A similar attack by gall midges was noticed in two grasses in the paddy fields, namely, *Ischæmum ciliare*, and *Eleusine indica*, but the flies from these were not reared, and so the identity of the insects with those on rice cannot be definitely stated.

No method of controlling the pest has been brought into use among the people, except the use of early varieties, and transplanting at as early a date as possible, Early varieties are, however, unfortunately not the highest yielding types. But the earliest possible sowing and transplanting in view of possible serious attack in any year seems worth while pushing in this and in other similar areas. [R. M. HEGDEKATTI.]

VEGETATIVE PROPAGATION OF COTTON PLANTS.

EVERY worker on the cotton plant feels sooner or later the need of some rapid and easy method of propagating a single plant on a large scale. The need is felt most urgently when it is desired to effect a rapid multiplication of a pure line up to commercial proportions. It also arises in genetics where a large number of seeds is often required from a single plant in order to decide questions of doubtful segregation, ratios, etc. In the genetic studies now being carried on in Trinidad, several cases have been met with of plants, which, though valuable from a genetic point of view, are subnormal in vigour, and which can best be kept alive by grafting on to a more vigorous stock.

Cotton may be budded, grafted, or grown from cuttings. Budding of cotton was first carried out in Hawaii (1909), where E. C. Smith was able to bud desirable types of Carovonica cotton on to stocks of poorer quality.[1] The writer budded large numbers of cotton in St. Vincent (1917), and found that the West Indian perennial,

[1] Annual report of the Hawaii Agricultural Experiment Station.

or tree cotton (*G. purpurascens*), was an exceptionally good stock for Sea Island cotton.[1]

Meade, in the United States, grafted American on to Indian cotton, and *vice versa.* The propagation of cotton from cuttings was successfully attempted in Hawaii (loc. cit.), and Longfield Smith, using this method in St. Croix in 1913, was also able to strike hardwood cuttings, though the percentage of successes was not high. The writer found in St. Croix that soft wood cuttings in sand rooted in about 10 per cent. of cases. Experiments carried on in England in the greenhouse at the Shirley Institute in 1923-26 showed that in lower temperatures, circa 70° to 78° F., softwood cuttings would root without the slightest difficulty in a few days.

A simple method for the rapid propagation of herbaceous plants has recently been described by Blakeslee and Farnham,[2] and is termed by them " bottle grafting." Mr. E. E. Cheesman successfully applied this method to cotton at my suggestion two years ago, and since then several hundred plants have been grafted.

The method consists in utilizing seedlings of perennial cottons as stocks for the less vigorous Sea Island, Egyptian, and Upland types. The seeds are sown in bamboo pots and are grafted when a few inches high. A thin slice about 1 inch long is cut out of the side of the stock, and a similar slice out of the scion—a young shoot about 3 inches long. The two cut surfaces are fitted together and firmly wrapped with ordinary knitting wool. The cut end of the scion is placed in a tube containing water, and this serves to prevent the scion wilting until union has taken place. The head of the stock may be cut off in three weeks and the water removed.

The importance of this method to cotton-breeding work cannot be over-emphasized, and it is described here for the benefit of cotton workers in other countries. From a single plant during the growing season several hundred plants can be obtained in a few months, and any desirable strain propagated rapidly. Finally, it should be noted that, by grafting, a single plant may be made to produce enough lint for a spinning test. [S. C. HARLAND in *Empire Cotton Growing Review*, Vol. IV, No. 1.]

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

BRANCHED COTTON HAIRS.

Branched hairs have been found amongst Asiatic types of cotton, as also in Upland American and Sea Island types. In *Gossypium Stocksii*, a type of cotton in

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[1] Harland, S. C. Notes on Resistance to Cotton Leaf Blister Mite, with special reference to Budded Cotton and to Cotton Hybrids. *W. Ind. Bull.*, XVI, pp. 78-81.

[2] Blackeslee, A. F. and Farnham, M. E. Bottle grafting. *Jour. of Heridity*, Vol. XIV, No. 4.

some respects primitive, hairs occur within the capsule not only on the seed coat but also on the capsule wall and many of these hairs show branching. A photograph is reproduced showing a mass of capsule wall carrying a bifurcate hair with a very short basal part embedded in the wall. There is a similar one with a longer base and hairs with shorter side branches can be seen in several places. In the material employed the hairs were some 8-10 mm. long. It seems probable that in the modern forms of *Gossypium* the branched hair has become suppressed and usually developes only tardily and to a limited extent in the form of fuzz. Plants of *G. Stocksii* from the Sind desert growing under the authors' observation show no signs of any stipular glands at the base of the clawed bracteoles and the flowers are small and of a pale sulphur yellow totally different from that of Asiatic cottons generally. The pollen grains, in the character of their spines, differ from other Asiatic *Gossypium*; thirteen chromosome bodies have been found in the developing pollen grain. [*Nature*, 1927, **119**, 745. W. YOUNGMAN and S. S. PANDE.]

GLABROUS COTTON PLANT.

The plant appeared on the Government Farm at Dharwar, India. A Burmese variety of *Gossypium neglectum* had been self-fertilized from 1919, and only the self-fertilized seed used for sowing in each generation, of which there had been one per annum. The variety had normally had simple and stellate hairs on stem, petiole and leaf. The variety bred true for this character of hairiness until 1925 in which season one plant which was entirely glabrous appeared. The normal plant has a ginning percentage of about 30 but the hairless plant had no lint at all although its seeds showed the shorter " fuzz ". The petal length was also shorter than normal, averaging 17 mm. as against the normal 35 mm. The plant was self-fertilized and seeds were produced. In the season of 1926-27 the seeds were sown, giving 80 plants all showing absolute hairlessness, lack of lint, and short petals. This new type appears to be a genuine mutant. Its behaviour in further generations and in crosses is being studied. [*Nature*, 1927, **119**, 747. G. L. KOTTUR.]

SUSCEPTIBILITY OF COTTON PLANT TO WILT.

THE author describes the symptoms of the wilt disease of cotton growing areas of Egypt, chiefly in the Delta region. The plants are infected in the seedling stage through the root system and generally die owing to a complete rotting of the roots. Different varieties of cotton show a marked variation in susceptibility to the disease. Sakel is extremely susceptible, while Ashmouni and Zagora are immune. Breeding experiments have resulted in the isolation of four strains of Sakel, which are of good quality, and which so far seem to be quite immune from wilt. [*Rev. Appld. Mycol.*, 1927, **6**, 290 from *Congress. Intern. Fed. Master Cotton Spinners' Manufacturers Assn., Egypt*, 1927, 3 pp. T. E. FAHMY.]

COTTON ROOT-ROT DISEASE.

Root-rot, caused by *Rhizoctonia bataticola*, and Violet Root-rot, caused by *Rhizoctonia crocorum*, have recently affected several varieties of cotton at the Research Station, Trinidad. Both diseases have previously been unrecorded in the West Indies and the fungus causing Violet Root-rot has hitherto not been recorded on the cotton plant anywhere. Field observations in Trinidad show that Nanking, Dharwar-American and Sea Island AN are susceptible to both diseases, Broach Type 1A9 is susceptible to *R. crocorum*, and Cawnpore (*G. arboreum*), Million Dollar, Buri from Nagpur and Upland Cassava are susceptible to *R. bataticola*. [*Tropical Agri.*, 1927, **4**, 88. H. R. BRITON-JONES.]

" IDEAL " SOIL.

The theory of the capillary behaviour of moist soil is further amplified for the ideal case and its relationship to various soil properties considered. Over part of the moisture range which has been dealt with by other authors it is found that there are alternative forms for the water distribution. This appears to explain why some differences of opinion have been expressed regarding some of the main points presented in a previous paper (Cf. C. 1925, 154 and C. 1926, 116). The theory is considered in relation to capillary rise in soils as well as to the problem of cohesion previously dealt with. It is shown that the moisture distribution attained by capillary rise can be inferred from simple direct measurement of the suction pressure. Various other experimental illustrations of the theoretical conclusions are introduced. It is shown that the suction or pressure deficiency which is necessary to draw an air-water interface into the pores of a soil is one that characterizes the capillary behaviour over a considerable moisture range and the term " entry value " is applied to it. From a complete suction curve it is possible to infer a size distribution curve for the soil interstices analogous to the treatment of particle size in mechanical analysis of soils. The results of a number of suction measurements on materials of a granular nature are given. [*Jour. Agri. Sci.*, 1927, **17**, 265-290. W. B. HAINES.]

CONTROL OF BLACK ARM DISEASE.

Experiments were carried out at Khartoum to test the effect of treating Egyptian Sakel cotton seed with sulphuric acid on germination and on the control of black arm. Seed treated in the proportion of 500 grm. to 100 c. c. concentrated acid for 1 hour, then washed in 2 litres of water for 10 mins. and either sown at once or dried and then sown, gave a germination of 95 per cent.; seed treated, dried and stored for 6 months showed 92 per cent. germination. The treated seed gave better germination and plant growth than untreated seed. Delinting with sulphuric acid did not fully free the seed from the black arm organism, but it delayed the appearance of the disease. [*Rev. Appld. Mycol.*, 1927, **6**, 225 ; from *Soil Science*, 1927, **23**, 1-3. R. G. ARCHIBALD.]

OCCURRENCE OF BLACK ARM DISEASE ORGANISM.

The author was unable to obtain *Bacterium malvacearum* from the lint, fuzz, or from the coats of the seeds. Experiments are described which indicate that the seed was infected internally. No evidence could be found incriminating soil and irrigation water and no epidemiological evidence exists in the Sudan pointing to transmission by insects; infection trials with flea-beetles, thrips, aphis, stem borer and white ants resulted negatively. The organism's feeble powers of resistance to sunlight, dessication and high temperature preclude the possibility of its survival in ginning factories. *Rev. Appld. Mycol.*, 1927, **6**, 225; from *Soil Science*, 1927, **23**, 5-9. R. G. ARCHIBALD.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

The services of MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist, Pusa, have been placed at the disposal of the Foreign and Political Department with effect from 16th November, 1927.

MR. P. G. MALKANI, B.Sc., M.R.C.V.S., has been appointed Temporary Veterinary Research Officer, Imperial Institute of Veterinary Research, Muktesar, from 15th July, 1927.

MR. T. F. MAIN, M.B.E., B.Sc., has been appointed Director of Agriculture, Bombay, *vice* Dr. Harold H. Mann, retired.

MR. K. HEWLETT, O.B.E., M.R.C.V.S., Principal, Bombay Veterinary College, has been granted, with effect from 21st June, 1928, leave for six months and 1 day.

MR. R. C. BROADFOOT, N.D.A., Deputy Director of Agriculture, Madras, on return from leave, has been posted to the Sixth Circle.

MESSRS. W. GREGSON, N.D.A., and J. W. GRANT, M.A., B.Sc., Deputy Directors of Agriculture, Burma, have been confirmed in their appointments in the Indian Agricultural Service.

REVIEW

An Illustrated Key to the Identification of the Anopheline Larvæ of India, Ceylon and Malaya.—BY C. STRICKLAND and K. L. CHOUDHURY. Pp. xii+68. [Calcutta and Simla : Thacker, Spink & Co.] Price, Rs. 4-8.

Of the many people engaged in or called on to combat malaria very few are entomologists. "Control the Anopheles and you control malaria" is the slogan of malariologists. But officers engaged in malaria control in India are usually not whole-time malaria officers, and many circumstances stand in the way of their acquiring expert knowledge of mosquitoes, their habits and methods of controlling them. Prof. C. Strickland, the senior author of the book under review, has certainly realized what could be done to mitigate this defect. Two years ago he brought out "A short key to both sexes of the Anopheline species of India, Ceylon and Malaya." and now in collaboration with Mr. K. L. Choudhury he has prepared "An illustrated key to the identification of the Anopheline larvæ of India, Ceylon and Malaya."

Facility for identifying mosquito larvæ is often more necessary than for adults, as the former would not only save time and labour but will also supply the required specific name of the insect without the risk of failure that often attends when a larva has to be bred into the adult. The usefulness of the present key cannot be over-estimated and the authors deserve the gratitude of medical men, sanitarians and entomologists. The clear and large drawings are excellent. Besides the actual key, there are included in this book simple instructions for the preparation of larvæ for microscopic examination and the use of the microscope, and chapters dealing with collecting and transporting specimens and the geographical distribution and larval habits of the species of the Anophelines, all of which appearing in this handy form are of no small help to those who have to deal with the great malaria problem, to which the public are now waking up. The book is indeed a very fine achievement, [P. V. I.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Plant Ecology, by W. B. McDougall. Pp. 326. (London : Henry Kimpton.) Price, 14*s.*
2. Farm Projects and Problems, by K. C. Davis. (*Farm Life Text Series.*) (Philadelphia and London : J. B. Lippincott.) Price, 7*s.* 6*d.* net.
3. Horticulture, by K. C. Davis. (*Farm Life Text Series.*) (Philadelphia and London : J. B. Lippincott.) Price, 7*s.* 6*d.* net.
4. Animal Nutrition and Veterinary Dietetics, by R. G. Linton. (*Edinburgh Veterinary Series.*) Pp. 411. (Edinburgh : W. Green and Son.) Price, 21*s.* net.
5. The Evolution of the English Farm, by M. E. Seebohm (M. E. Christie). Pp. 376. (London : George Allen and Unwin, Ltd.) Price, 16*s.* net.
6. The Economics of Small Holdings : A study based on a survey of small scale Farming in Carmarthenshire, by Thomas Edgar. Pp. xii+132. (Cambridge : At the University Press.) Price, 4*s.* 6*d.* net.

Since our last issue, the following publications have been issued by the Imperial Department of Agriculture in India :—

Memoirs.

1. The Kolamba Rice of the North Konkan and its Improvement by Selection, by R. K. Bhide and S. G. Bhalerao, B.Ag. (Botanical Series, Vol. XIV, No. 7.) Price, Re 1-4 or 2*s.*
2. Experiments on the Feeding of Sorghum Silage and Concentrate to S indi Calves, by F. J. Warth, M.Sc., and Shari Kant Misra. (Chemical Series, Vol. IX, No. 5.) Price, As. 9 or 10*d.*
3. Four New Gall Midges, by Dr. E. P. Felt ; The Citrus Psylla (*Diaphorima citri*, Kuw.), by M. Afzal Husain, M.Sc., M.A. (Entomological Series, Vol. X, Nos. 1 and 2.) Price, Rs. 1-2 or 2*s.*
4 Bacterial Soft Rot of Garden Poppy, by C. S. Ram Ayyar, B.A. (Bacteriological Series, Vol. II, No. 2.) Price, As. 5 or 6*d.*

Bulletin.

5 List of Publications on Indian Entomology, 1926 (compiled by the Offg. Imperial Entomologist and the Imperial Entomologist). (Pusa Bulletin No. 168.) Price, As. 10 or 1*s.*

List of Agricultural Publications in India from 1st February to 31st July 1927

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	*The Agricultural Journal of India*, Vol. XXII, Parts II, III and IV. Price, Re. 1-8 or 2*s.* per part. Annual subscription, Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	*The Journal of the Central Bureau for Animal Husbandry and Dairying in India*, Vol. I, Parts I and II. Annual subscription, Rs. 2-8 ; Single copy As. 10.	Ditto . . .	Ditto.
3	Review of Agricultural Operations in India, 1925-1926. Price, Rs. 2-6 or 4*s.* 3*d.*	Issued by the Agricultural Adviser to the Government of India.	Ditto.
4	Sampling for Rice Yield in Bihar and Orissa. Pusa Agricultural Research Institute Bulletin No. 166. Price, As. 7 or 9*d.*	J. A. Hubback, I.C.S. .	Ditto.
5	Agricultural Statistics of India, 1924-25. Vol. I. Re. 1-5 or 2*s.* 3*d.*	Issued by the Department of Commercial Intelligence and Statistics, India.	Ditto.
6	Agricultural Statistics of India, 1924-25. Vol. II. Re. 1-4 or 2*s.*	Ditto . . .	Ditto.
7	Annual Report of the Royal Botanic Gardens and the Gardens in Calcutta and of the Lloyd Botanic Gardens, Darjeeling, for the year 1926-27. Price, As. 4 or 6*d.*	Superintendent, Royal Botanic Gardens, Calcutta.	Bengal Secretariat Book Depot, Calcutta.
8	Report of the Botanical Survey of India for 1925-26.	Issued by the Director, Botanical Survey of India.	Government of India Central Publication Branch, Calcutta.
9	A note on varieties of paddy grown on the Samalkota Experiment Station, Godavari District. Madras Department of Agriculture Leaflet No. 46. (English and Telegu). . .	A. C. Edmonds. .	Government Press, Madras.
10	Villagers' Calendar, 1927-28 (Tamil, Telegu and Kanarese).	Issued by the Department of Agriculture, Madras.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
11	Year Book, 1926, of the Department of Agriculture, Madras.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
12	Annual Reports of Experiment Stations, 1926-27.	Ditto . . .	Ditto.
13	Report on the Operations of the Department of Agriculture, Madras, for 1926-27.	Ditto . . .	Ditto.
14	Annual Reports of the Subordinate Officers of the Department of Agriculture, Madras, for 1926-27.	Ditto . . .	Ditto.
15	The Fig Industry in Asia Minor. Bombay Department of Agriculture Bulletin No. 131 of 1926. Price, As. 4-6.	Dr. G. S. Cheema . .	Government Central Press, Bombay.
16	Murrah Buffaloes in Sind. Bombay Department of Agriculture Bulletin No. 134 of 1927. Price, As. 2-6.	A. M. Ulvi . . .	Yeravda Prison Press.
17	An improved method of growing turmeric in the Deccan. Bombay Department of Agriculture Bulletin No. 135 of 1927. Price, As. 4.	H. M. Desai . . .	Ditto.
18	Cattle Breeding in the Bombay Presidency; Principles and Progress. Bombay Department of Agriculture Bulletin No. 136 of 1927. Price, As. 5-6.	E. J. Bruen . . .	Ditto.
19	Notes on the Lemon industry in Italy. Bombay Department of Agriculture Bulletin No. 137 of 1927. Price, As. 2.	Dr. G. S. Cheema . .	Ditto.
20	Annual Report of the Department of Agriculture in the Bombay Presidency for 1925-26. Price, Re. 1-12.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
21	Monthly and Annual Rainfall Table in the Province of Bengal for 1926.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
22	Season and Crop Report of Bengal for 1926-27.	Ditto . . .	Ditto.
23	Paddy Seed Farms . . .	Ditto . . .	Ditto.

General Agriculture—contd

No.	Title	Author	Where published
24	Artificial Farmyard Manure (Bengali). Bengal Department of Agriculture Leaflet No. 1 of 1927.	R. S. Finlow, B.Sc., F.I.C., Director of Agriculture.	Sreenath Press, Dacca.
25	Report on Demonstration work carried out in the Northern Circle, Central Provinces, together with Reports on Seed and Demonstration Farms for the year 1925-26. Price, Re. 1-14.	J. H. Ritchie, M.Sc., Deputy Director of Agriculture, Northern Circle, B. L. Dubey, Extra Assistant Director, Jubbalpore, and Govind Prasad, Extra Assistant Director, Chhindwara.	Government Press, Nagpur.
26	Report on Demonstration work carried out in the Plateau Sub-circle, Central Provinces, together with reports on Seed and Demonstration Farms, Betul and Seoni, for the year 1925-26. Price, Re. 1-7.	E. A. H. Churchill, Assistant Director of Agriculture, Chhindwara, and Govind Prasad, Extra Assistant Director, Chhindwara.	Ditto.
27	Report on Demonstration work carried out in the Southern Circle, Central Provinces, together with reports on the Seed and Demonstration Farms, Waraseoni and Sindewahi, and the Cattle Breeding Farm, Sindewahi, for the year 1925-26. Price, Re. 1-10.	G. K. Kelkar, Extra Assistant Director of Agriculture, Bhandara, J. C. McDougall, Deputy Director of Agriculture, Southern Circle, Nagpur, and T. K. Ghatpande, Extra Assistant Director, Wardha.	Ditto.
28	Report on Demonstration work carried out in the Eastern Circle, Central Provinces, together with reports on the Seed and Demonstration Farms at Chandkhuri, Bilaspur and Drug with that of Cattle Breeding Stations attached thereto for the year 1925-26. Price, Rs. 2-6.	T. L. Powar, Deputy Director of Agriculture, Eastern Circle, Raipur, N. G. Bhoot, Extra Assistant Director of Agriculture, Drug, and D. R. Mohrikar, Extra Assistant Director of Agriculture, Raipur.	Ditto.
29	Report on Demonstration work carried out in the Western Circle, Central Provinces, together with reports on the Seed and Demonstration Farm and Cattle Breeding Farms of that Circle for the year 1925-26, Vol. I. Price, Re. 1-6.	S. G. Mutkekar, Deputy Director of Agriculture, Western Circle, M. S. Barker, Extra Assistant Director, Akola, and S. L. Mohommad, Extra Assistant Director, Amraoti.	Ditto.
30	Report on the District Demonstration work carried out in the Western Circle, Central Provinces, during the year 1925-26, Vol. II. Price, Rs. 1-6.	S. L. Mohammad, Extra Assistant Director, Amraoti, and M. S. Barker, Extra Assistant Director, Akola.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
31	Annual Reports on Experimental Farm, Akola, and the Experimental Farm attached to the Agricultural College, Nagpur, for the year 1925-26. Price, Re. 1-10.	R. H. Hill, Offg. Economic Botanist for Cotton, C. P., and H. E. Annett, D. Sc. (Lond.), F.I.C., M.S. E.A.C. Offg. Principal, Agricultural College, Nagpur.	Government Press, Nagpur.
32	Annual Reports on Experimental Farms of the Southern and Eastern Circle, Central Provinces, *viz.*, Tharsa and Raipur, for the year 1925-26. Price, Re. 1-8.	J. C. McDougall, Deputy Director of Agriculture, Southern Circle, Nagpur, and T. L. Powar, Deputy Director of Agriculture, Eastern Circle, Raipur.	Ditto.
33	Annual Reports on Experimental Farms of the Northern and Plateau Circles, Central Provinces, Powarkhera, Adhartal, Chhindwara, with that of Cattle Breeding Stations attached thereto for the year 1925-26. Price, Rs. 2-5.	J. H. Ritchie, M.Sc., Deputy Director of Agriculture, Northern Circle.	Ditto.
34	Report on the Cattle Breeding Operations in the Central Provinces and Berar for the year 1925-26.	S. T. D. Wallace, B.Sc. Deputy Director, in charge Animal Husbandry, C. P.	Ditto.
35	Report on the Agricultural College, Nagpur, Chemical, Botanical, Mycological, Entomological Research, Agricultural Engineer's Section and Maharajbagh Menagerie, 1925-26. Price, Re. 1-5.	H. E. Annett, D. Sc. (Lond.), F.I.C., M.S.E.A.C., Offg. Principal, Agricultural College; H. E. Annett, D.Sc. (Lond.), F.I.C., M.S.E. A.C., Agricultural Chemist; R. H. Hill, offg. Economic Botanist for Cotton and D. N. Mahta, Second Economic Botanist; J. F. Dastur, Mycologist; J. L. Khare, Entomological Assistant; H. P. Chitari, Assistant to Agricultural Engineer; H. E. Annett, D.Sc. (Lond.), F.I.C., M.S.E.A.C., Offg. Principal, Agricultural College.	Ditto.
36	Comments by the Director of Agriculture on the Return of expenditure on the Provincial and District Gardens in the Central Provinces and Berar for the year ending 31st March 1926. Price, As 7.	Issued by the Director of Agriculture, C. P.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
37	Maintenance of Purity of the improved Cottons.	B. Ram Prasad, Assistant Economic Botanist to Government, U. P., Cawnpore.	Government Press, Allahabad.
38	A note on Water Hyacinth in the United Provinces.	R. L. Sethi, Economic Botanist to Government, U. P., Cawnpore.	Ditto.
39	Report on the working and the Administration of the United Provinces Government Gardens for the year 1925-26. Price, As. 9.	Issued by the Director of Agriculture, U. P.	Ditto.
40	Annual Report of the Department of Agriculture, Bihar and Orissa, for 1925-26.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gulzarbagh.
41	Agricultural Statistics of Bihar and Orissa, for 1925-26.	Ditto . . .	Ditto.
42	Season and Crop Report of Bihar and Orissa.	Ditto . . .	Ditto.
43	Report on Cattle Census of Bihar and Orissa, held in 1925.	Ditto . . .	Ditto.
44	Leaflet on Ammophos . .	Ditto . . .	United Press, Ltd., Bhagalpur.
45	Annual Report of Principal, Agricultural College, Mandalay, for 1926.	Issued by the Department of Agriculture, Burma.	Government Printing, Rangoon.
46	Agricultural leaflets in book form in two volumes.	Ditto. . . .	Ditto.
47	Annual Report of the Department of Agriculture, Punjab, for 1925-26.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
48	Annual Report of the Lawrence Gardens, Lahore, for 1925-26.	Ditto . . .	Ditto.
49	Prospectus of the Punjab Agricultural College, Lyallpur, for 1927.	Ditto . . .	Ditto.
50	Seasonal Notes (April 1927) .	Ditto . . .	Ditto.
51	Harmful effects of close planting, various methods of laying out of gardens, distance necessary for fruit trees.	Ditto . . .	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
52	Heading back of young nursery trees.	Issued by the Department of Agriculture, Punjab.	Government Printing Punjab, Lahore.
53	Hints on the management of sheep in the Punjab.	Ditto . . .	Ditto.
54	The hatching of Eggs by natural methods.	Ditto . . .	Ditto
55	Study of soils for Fruit Gardens	Ditto . . .	Ditto
56	The rearing, feeding and diseases of chicks and young poultry.	Ditto . . .	Ditto.
57	Protecting trees from sunburnt .	Ditto . . .	Ditto.
58	Cattle and Dairying in the Punjab (Reprinted).	A. M. Stow . . .	Ditto.
59	*Quarterly Journal of the Indian Tea Association.* Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Calcutta Orphan Press, Calcutta.
60	*Indian Scientific Agriculturist* (Monthly). Annual subscription, Rs. 4.	H. C. Sturgess, Editor, J. W. McKay, A.R.C.Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Company, 52-53, Bowbazar Street, Calcutta.
61	*Rural India* (Monthly). Single copy, As. 6, Annual Subscription, Rs. 3.	A. Swaminatha Ayyar .	President, Forest Panchayat Banking Union, Madras.
62	The *Journal of the Mysore Agricultural and Experimental* Union (Quarterly). Annual subscription, Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
63	The *Journal of the Madras Agricultural Students' Union* (*Monthly*). Annual subscription, Rs. 4; single copy, As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
64	The *Planters' Chronicle* (Weekly)	United Planters' Association of South India.	Diocesan Press, Post Box 455, Madras.
65	The *Nagpur Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 3.	R. A. Ramayyar, and R. B. Ekbote, Editors.	Udyama Desha Sevak Press, Nagpur.
66	*Poona Agricultural College Magazine* (Quarterly). Annual subscription Rs. 2-8; single copy, As. 10.	College Magazine Committee, Poona.	Agricultural College, Poona.
67	The *Old Boys' Magazine, Agricultural College, Cawnpore* (Quarterly). Price, As. 8 per copy; Annual subscription, Rs. 2.	L. Saksena, L.Ag., Editor.	Cawnpore Printing Press.

No.	Title	Author	Where published
	General Agriculture—concld.		
68	The *Allahabad Farmer* (Quarterly). Single copy, As. 8; per year Rs. 2.	W. B. Hayes, E. W. Jeremy and J. N. Shivpuri.	The Mission Press, Allahabad.
69	The *Bengal Agricultural Journal* (Quarterly). (In English and Bengali.) Annual subscription, Re. 1-4, single copy, As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
	AGRICULTURAL CHEMISTRY		
70	Some Digestibility Trials on Indian Feeding Stuffs, II. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 3. Price, As. 10 or 1*s*.	P. E. Lander, M.A., D.Sc., A.I.C., and Pandit Lal Chand Dharmani, L.Ag., B.Sc. (Ag.).	Government of India Central Publication Branch, Calcutta.
71	The Effect of Manuring a crop on the Vegetative and Reproductive capacity of the Seed. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 4. Price, As. 14 or 1*s*. 6*d*.	B. Viswanath, F.I.C., and N. Surianarayana, B.Sc.	Ditto.
	BOTANY		
72	Studies in Gujarat Cottons, Part IV: Hybrids between Broach-deshi and Goghari varieties of *Gossypium herbaceum*. Memoirs of the Department of Agriculture in India, Botanical Series. Vol. XIV, No. 4, Price, As. 14 or 1*s*. 6*d*.	M. L. Patel, M.Ag., and S. J. Patel, B.Ag.	Ditto.
73	The Indigenous Cotton types of Burma. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIV, No. 5. Price, As. 9 or 10*d*.	T. D. Stock, B.Sc., D.I.C., A.R.C.S.	Ditto.
74	A Scheme of Classification of the Varieties of Rice found in Burma. Pusa Agricultural Research Institute Bulletin No. 167. Price, As. 6 or 8*d*.	R. A. Beale . . .	Ditto.
75	The classified list of the plants of Burma.	A. M. Sawyer and Daw Nyun.	Government Printing, Rangoon.
	MYCOLOGY		
76	A Study of *Fusaria* common to Cotton plants and Cotton soils in the Central Provinces. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIV, No. 6. Price, As. 5 or 6*d*.	Jiwan Singh, M.Sc. . .	Government of India Central Publication Branch, Calcutta.

No.	Title	Author	Where published
	ENTOMOLOGY		
77	Some New Indian Miridæ (Capsidæ). Memoirs of the Department of Agriculture in India, Entomological Series, Vol. X, No. 4. Price, As. 6 or 8*d*.	E. Ballard, B.A., F.E.S. .	Government of India Central Publication Branch, Calcutta.
78	The Catalogue of Indian Insects, Part 12, Tabanidæ. Price, Re. 1-12 or 3*s*.	Ronald Senior-White, F.E.S., F.R.S. T. M. & H.	Ditto.
	VETERINARY		
79	Annual Report on the Punjab Veterinary College, Civil Veterinary Department and Government Cattle Farm, Hissar, 1925-26.	Issued by the Department of Agriculture, Punjab.	Government Printing Punjab, Lahore.
80	Annual Report of the Camel Specialist, Sohawa, 1925-26.	Ditto . . .	Ditto.
81	Prospectus of the Punjab Veterinary College, Lahore, for 1927.	Ditto . . .	Ditto.
82	*The Indian Veterinary Journal* (Quarterly). Annual subscription, Rs. 4 for members of All India Veterinary Association and Students ; Rs. 8 for others	P. Srinivasa Rao, G.M.V.C., Editor.	Methodist Publishing House, Madras.

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